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Mobile Radio Technology

The journal of mobile communications technology

Novel cellular antennas, p. 10

**Performance standards
Cellular test equipment
Controlling site interference
Using radiating cable systems**



AN INTERTEC PUBLICATION

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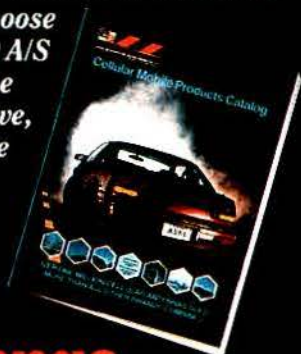
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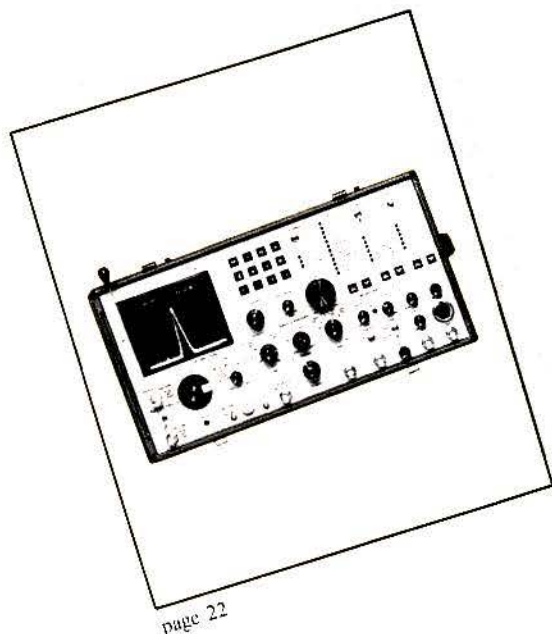
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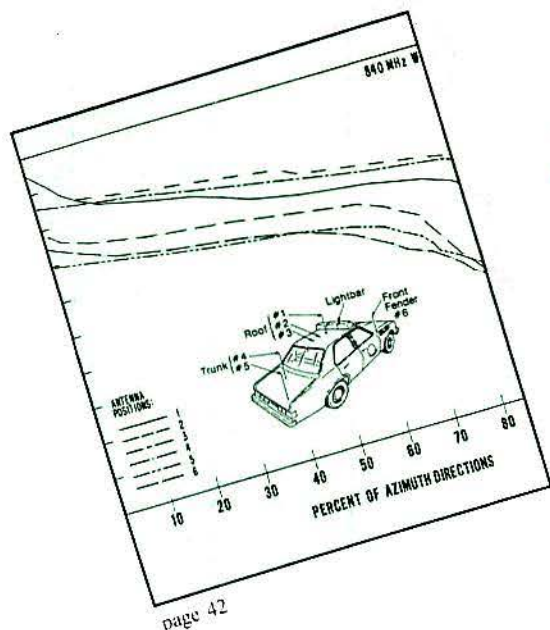
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On the cover: Three cellular telephone antennas offer no-hole mounting options. From left: A Decal serpentine array antenna, an Antenna directional discontinuity ring radiator antenna and an On-Glass whip antenna. Turn to page 10 to read details about the two newest types.

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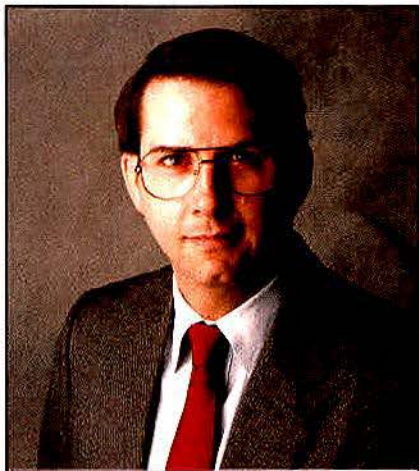
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An idea whose time has not yet come



Some private radio license applicants, service representatives, equipment dealers and consultants want to bypass frequency coordinators and send applications straight to the FCC. Proposed "direct access" regulation to allow that procedure has passed the first stage of consideration: the submission to the FCC of public comments and replies to those comments.

Frequency coordinators who handle the most applications see the proposal, PR Docket 88-548, as a loose thread that may unravel effective spectrum management. The FCC has given frequency coordinators the responsibility of choosing frequencies for license applicants, frequencies that the coordinators believe will result in the least interference and the most efficient spectrum use.

Radio users, service reps, dealers and consultants who feel restricted, mistreated and overcharged by frequency coordinators see direct access as a boon—a way to speed licensing and avoid fees charged for coordination.

Most private radio channels are shared by many licensees. Channel occupancy is highest where population is greatest. With business and industrial channels, the best that frequency coordinators can do is to load channels more or less equally. Whether their efforts result in equal channel loading is a matter of opinion.

With public safety channels, frequency coordinators add risks to communications related to the safety of life and property to the channel-congestion equation.

The direct access procedure may threaten the usefulness of radio communications. Direct access supporters say they can do a better job of finding their customers the best frequencies, and do it cheaper, than frequency coordinators can. Opponents say some who would use direct access want to activate radio systems on frequencies where they would cause interference, just for the sake of equipment sales and without regard for their customers or existing users.

Here are some typical opinions we hear:

- *Negative opinion #1:* Some licensees, service reps, dealers and consultants who support direct access have no regard for existing users and little regard for their customers. All they want is to put new users on the air quickly, and nobody will be able to resolve interference that results.

- *Positive opinion #1:* Licensees, service reps, dealers and consultants who want to use direct access are prepared to make a diligent analysis of co-channel users or to monitor potential frequency selections so carefully that they can make better recommendations than frequency coordinators do, and for less money.

- *Negative opinion #2:* Frequency coordinators are price-gougers who do not earn the money paid them and whose recommended frequencies are no better selected than if they were picked at random.

- *Positive opinion #2:* Frequency coordinators have no vested interest in equipment or engineering project sales. Most are trade associations that represent users they serve as frequency coordinators, so they are motivated to recommend frequencies with the lowest potential for interference.

Conditional licensing

The FCC already has announced plans to let some users activate their radios before processing their applications. Called "conditional licensing," the program has some limitations. Basically, it lets new two-way radio users begin operation when their applications have been frequency-coordinated and sent to the commission.

If the user exercises the direct access

procedure, operations might commence as soon as the application is sent to the FCC. Resolving interference that could result from such activations, whether well planned or not, would be formidable. Such activations would not immediately be reflected in the database. The risk of poor frequency coordinations would increase.

We know a few direct access supporters are unscrupulous. There may be more. We are *not* saying most direct access supporters have dark motives.

But the few who simply do not care how much interference new systems they sell may cause or receive could use direct access to activate users on channels where conflicts are certain. Such actions, especially in urban areas, could degrade spectrum management enough to limit the usefulness of radio communication to business, industrial and public safety users who rely on it.

Direct access is not a worthwhile idea in the form presented by the FCC.

—Don Bishop

PRIVACY

Volume 1, No. 5

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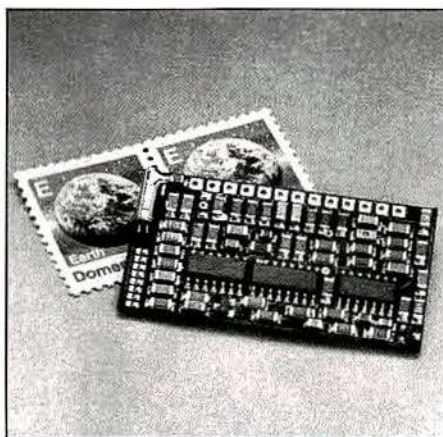
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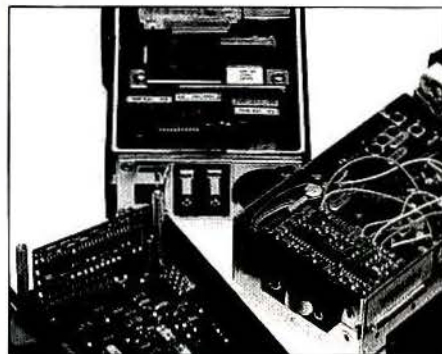
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Qualified technicians:

The old saw-again-about the lack of qualified radio service technicians (or electronic service technicians in general):

(1) It would appear that most service agencies want something for nothing—qualified people to walk in the door, prepared to work, without having to invest any money or time in training.

(2) The very *lack* of qualified people in this field may be laid directly at the feet of people running and making good money in this industry: owner-operators. These operators have done little to glorify the industry, to put the wage scales at a suitable level, or to make the vocation colorful and interesting. In a word, "radio people talk, but they seldom communicate."

(3) There probably *never* will be enough interested technicians in the future, based on the general "lack of interest" in young people today. So, instead of the continual "talk," why not

get *prepared* for the future.

(4) Young people today have little ability to communicate (read, write, speak). The possibility of on-the-job training further complicates the situation due to the fact that many owners of small shops and service managers at large shops who would have the training responsibility, have little ability to provide in-depth training when it is needed.

(5) The intuitive ability to de-bug electronic gear is further buried due to the use of high-tech service gear that precludes the need to "think" and put two plus two together.

(6) Electronics trade schools often no longer have any courses in radio communications technology. Young people think that solid-state chips and computers are "all there is." There still is a need for some basic dc theory instruction that goes back to vacuum tube use and that provides a firm foundation for solid service techniques and an under-

standing of theory.

(7) We in the industry support manufacturers who have created some of the problems that lead to "unqualified service technicians." We support manufacturers of the Japanese "rice boxes." Look at the service manuals. Listen to the lack of information available from service centers. What in hell was wrong with the decent service data provided with a GE-RCA-Motorola product? Could it also be that the new generations *cannot communicate* and do not know how to put together decent service data?

(8) This industry has many "certification" programs. *Where* has the industry "put its money where its mouth is" and done anything of value to prompt formal educational programs? The computer industry and others in that area of technology do. The National Burglar and Fire Alarm Association has, as an example, formal technical programs.

There was a time when many of the people in electronics, communications

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Letters to the editor

and what have you, were even licensed amateur radio people or had an interest in electronics as a hobby, or both, and they were the foundation of the industry 20 and 30 years ago. Today, those "interested" people believe that electronics is "computers" and "chips." Wonderful. That is not electronics.

The solution is for those who are looking for qualified people to "stop

talking and *communicate*." If those with the wherewithal in the industry cannot get the ideas across, enhance the position of "electronic service tech" as a vocation, then it is not the fault of that "unavailable qualified technician" that we always hear about that seems to be floating around out there "just out of reach."

If present-day products are supported and stay on course, pull the module

and send it to the service center.

Let us stop blaming that errant "qualified service tech." Let us assume the *responsibility* ourselves, pool the funds required, get into the educational sector that will support the program and do something about it.

Moreover, it might be time to make the military electronics educational process (and those poor souls who think they are really getting an education that will provide a job outside the military) aware of the fact that being able to service particular *systems* blindfolded does not an *electronics* technician make.

If the publishers of journals such as yours were *really* interested in a service to the industry, there would be considerably more articles based on field service experience, rather than isolated manufacturers' product descriptions.

If the shop owner and service manager made reading (such as evening homework) an employment requirement, we might see some progress. Of course, how many young people can read today.

If some publications such as the Ryder and Sams series, which simply were "How To Service Land Mobile Radios" and "How To Service Marine Radio," were updated. The broadcast industry has such manuals. The security industry has them. The sound and internal communications industry has them.

Experienced, *hands-on* technical writers are few and far between in this day and age. *And all the complainers writing the editors are too busy making a buck to want to help enhance the very industry that is their bread and butter.*

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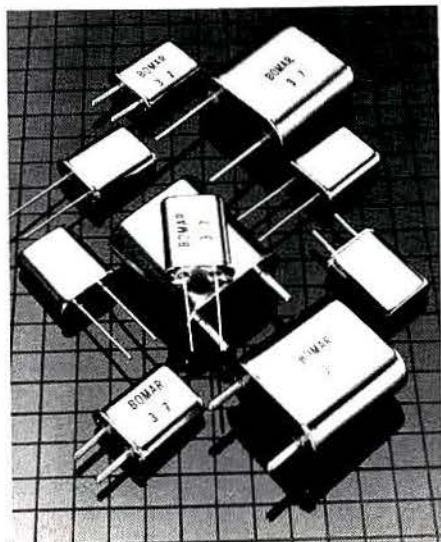
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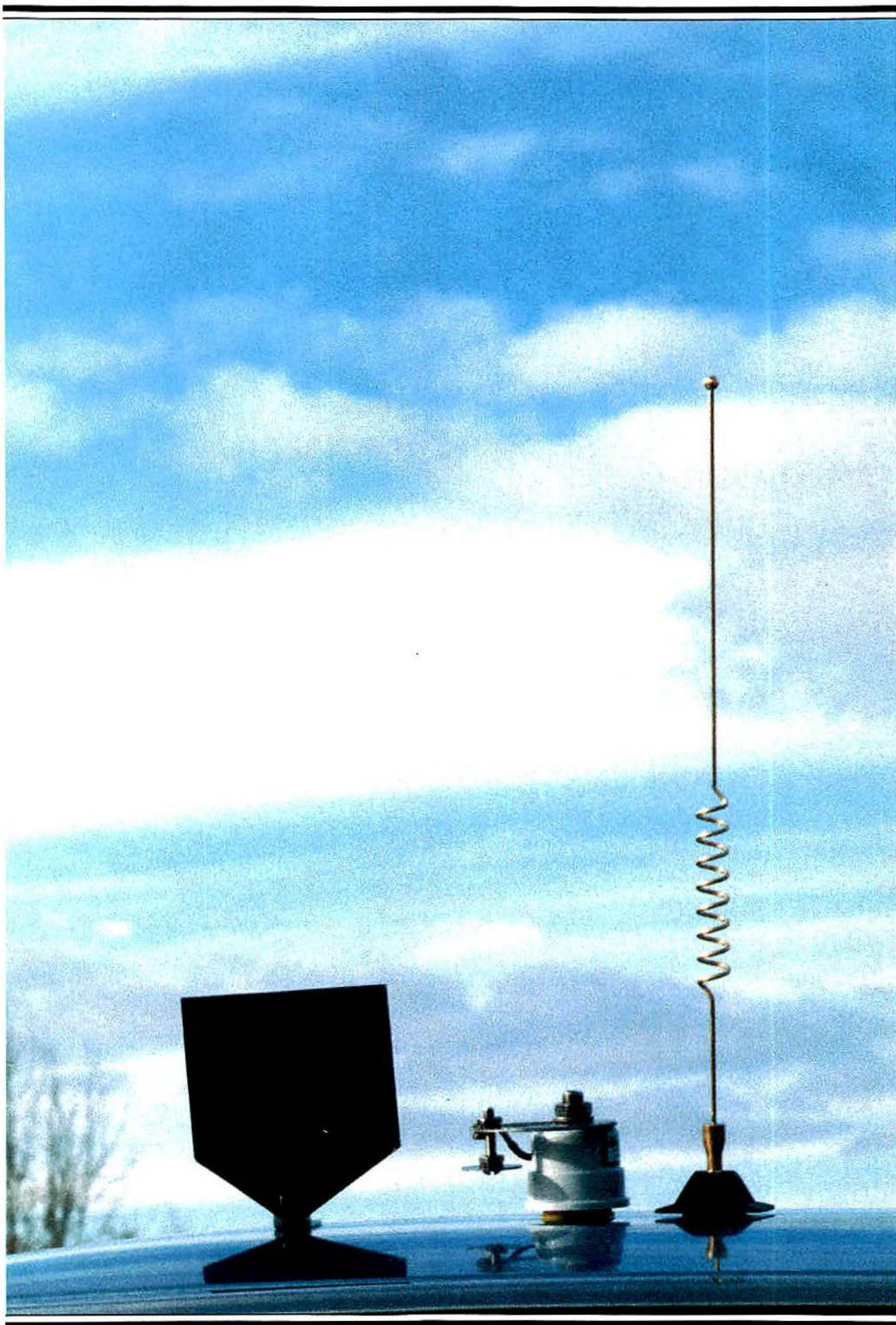
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Novel cellular antennas offer mounting options

With odd-sounding names such as serpentine array and directional discontinuity ring radiator, two new cellular mobile antennas use quite different technology from whips—and each other.

By Don Bishop
Editorial Director

More cellular telephone users choose glass-mount whip antennas than any other. They opt for glass-mount whip antennas to avoid having holes cut through their vehicles' exteriors.

Most glass-mount whip antennas represent various forms of vertical elements, including halfwave-over-halfwave and 5/8-wave-over-quarterwave collinear arrays. They are shaped like "pig-tails." The curl is a phasing coil (not a loading coil) that connects the two straight elements and keeps radio energy that passes between them in phase.

Two other antenna types, serpentine array and directional discontinuity ring radiator (DDRR), may be mounted without cutting holes.¹ The DDRR may be mounted on a shelf below the rear window and covered with a hat or a tissue box to conceal it. It also may be mounted using a hole through the car body. The serpentine array normally is mounted on the inside of the windshield.

Serpentine array

The Decal serpentine array antenna developed by Antennas America, Arvada, CO, takes the form of a 3" x 3" polystyrene film decal. The manufacturer embeds a 1.5mm x 50mm copper strip about 15 inches long inside the polystyrene. The strip contains 12 half-wave elements that resonate at frequencies from 800MHz to 925MHz. The decal normally is mounted at the top center of a windshield. (See Figure 1 above.)

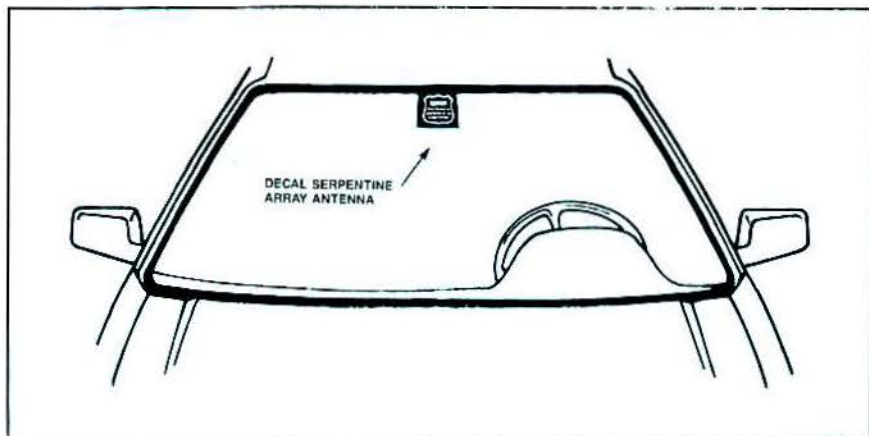


Figure 1. The Decal serpentine array antenna mounts inside the windshield.

The elements conform to a series-fed zig-zag pattern with ever-decreasing dimensions. They resemble a log periodic antenna whose element tips connect on alternate ends, every other one. Inductances shift the phase 90° between each serial element. (See Figure 2 on page 12.)

The company's chief scientist, Kevin Shoemaker, used a ladder network analysis program to design the antenna. "The program 'massaged' the ladder network for the right resonant lengths," Shoemaker said. "Space was a constraint. I tried variations of compression and ended up with a periodic pattern that seemed to do the trick."

Shoemaker has been designing antennas since he was 18. His first designs were for amateur radio cubical quad, monopole and multiband yagi antennas. Later came antenna design work as a technical specialist at Ball Aerospace and as a senior design engineer at Martin-Marietta. At Colorado Univer-

sity he taught radioastronomy, "which is really my background," he said. Other federal agencies where Shoemaker worked include the National Center for Atmospheric Research, the National Oceanic and Atmospheric Administration and the National Institute of Standards and Technology (formerly the National Bureau of Standards).

"We tested the serpentine array against the competition," Shoemaker said. "Compared to five glass-mount antennas tested, it works better than four and is comparable to one."

Shoemaker said the one-on-one test involved five car models, a serpentine array and the five glass-mount antennas. "We put each glass-mount antenna on each car and our antenna on each car. Using lab equipment, we tested signal strength and VSWR." VSWR is voltage standing wave ratio, a measurement that reveals how closely matched are antenna and feedline impedances. The closer the match, the better radio energy trans-

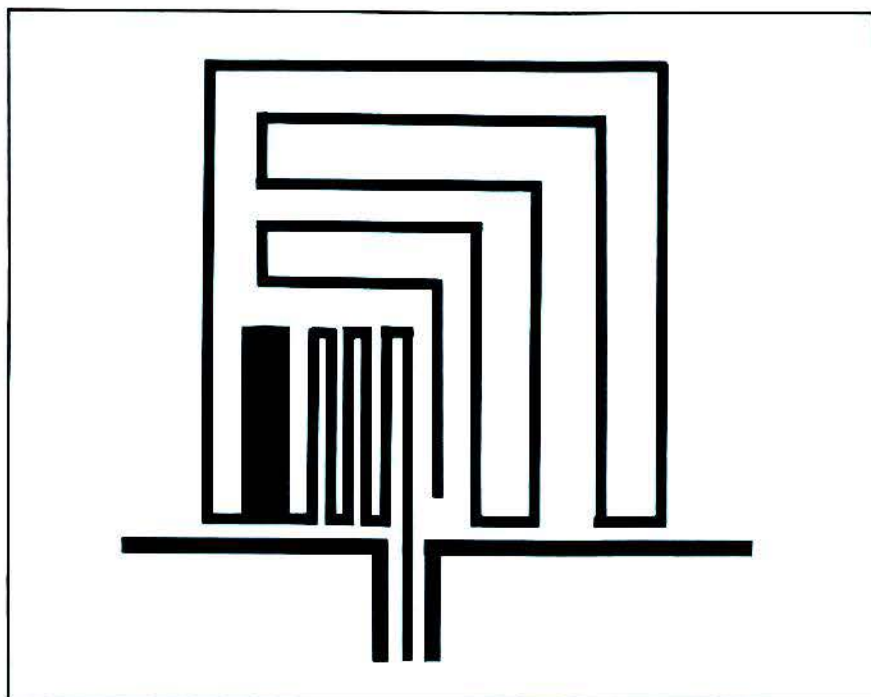


Figure 2. The copper foil pattern inside a sample serpentine array antenna has 12 half-wave elements. The long element connects to the coaxial cable's center conductor, the short elements to the braid. This configuration was used in an early production model and may not correspond with units currently on the market.

fers between them and the better the signal.

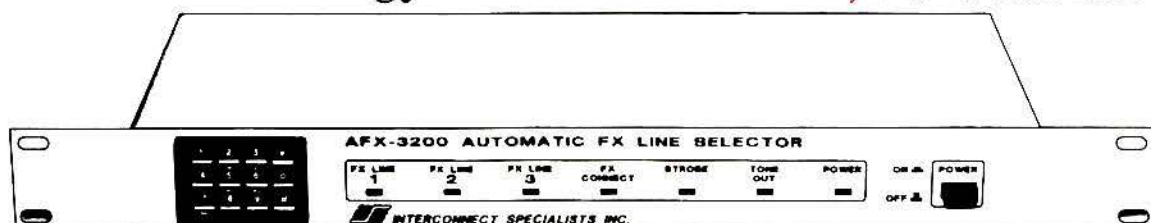
Impedance matching

The antenna uses a feedpoint circuit and a characteristic of window glass to match the impedances. The feedpoint circuit is a coaxial transition. "For lack of a better term, we call it a 'co-planar transition,'" Shoemaker said. "Additionally, we use the window glass' dielectric constant to load the antenna element." VSWR varies slightly with different window thicknesses, but the manufacturer reports less than 2:1 VSWR from 806MHz to 895MHz. The feedpoint circuit and window glass both contribute to the antenna's broadband characteristic, he said.

Shoemaker said glass-mount antennas he measured have about 1.3:1 VSWR at a particular frequency and the VSWR rises to 2.5:1 at band edges. "It is typical for a glass-mount antenna to have a VSWR peak within the band, too," he said.

To test signal strength, the five cars

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The AFX-3200 enables multiple interconnects, as used in trunked radio systems, to select one of four trunk lines, determined by the first three digits of the telephone number dialed. One AFX-3200 and one local line is required for each interconnect. Any number of interconnects and AFX-3200s can share up to three FX lines.

The AFX-3100 is similar to the 3200 but for single channel operation.



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- Digital Coded Squelch encode and decode
- DTMF encode and decode
- POCSAG pager testing, including alphanumeric
- Up to 33 tone sequences
- Waveform generator with Sine, Square, Sawtooth and Triangle waveforms
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- +5dBm Signal Generator output level
- And more...

The two enhanced, independent, audio generators, along with digital modulation capability, make this test set a real powerhouse when evaluating FSK NRZ digital tone systems.

For the testing needs of the cellular industry, the **2957A** continues to offer the diagnostic power of an engineering work station while retaining user friendly, pushbutton operation for entry level technicians in the service shop.

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- Revert to DC power supply
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What is the *real* bottom line? A *proven* cellular test set that continues to grow to meet the expanding needs of the industry.

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- Band III Trunking protocol

For further details on the above products, or to join the Marconi Users Group (MUG), contact your local Marconi Representative or call direct (800) 233-2955; Fax: (201) 934-9229 or write: Marconi Instruments, Inc. 3 Pearl Court Allendale, NJ 07401 • (201) 934-9050

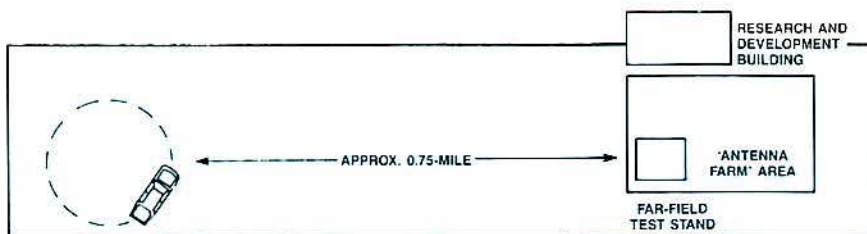


Figure 3. The serpentine array antenna's emission pattern and gain were compared to a reference halfwave dipole 0.75-mile from laboratory equipment, as well as five glass-mount antennas mounted on five car models driven in a circle at approximately the same distance.

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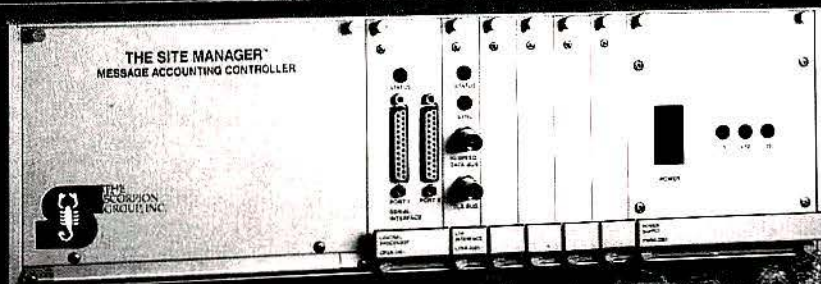
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each were driven in circles in an open field about three-quarters of a mile from lab equipment housed in the company's headquarters. (See Figure 3 at the left.) The lab's chart recorder drew graphs of signal strengths received from the cars. "Scientifically or standard-wise, there was nothing to control the distance between the car and the lab equipment."

Shoemaker reported these results: "There are more nulls and deeper nulls with the glass-mount antennas. The serpentine antenna tends to have fewer and shallower nulls. Its gain tends to increase 1dB toward the side of the car where it is mounted, but it generally has a hemispherical pattern." Shoemaker infers the hemispherical pattern from measurements made at 0° and 30° elevations. A radiation distribution plot, normally used to confirm a hemispherical pattern, was not made.

Tests were made with the serpentine antenna mounted on the windshield, side and rear windows. The strongest signal was received from the windshield-mount position. No interaction was observed between the antenna and the rearview mirror post.

A gain figure of 3dB is claimed for the antenna, using a standard halfwave dipole as a reference. Competitors' glass-mount antennas also measured 3dB gain, within a few tenths of a decibel, compared to the halfwave dipole used during the company's tests.

DDRR antenna

Com-Rad Industries, Grand Island, NY, has brought its Untenna directional discontinuity ring radiator antenna to the 800MHz band for cellular telephone and two-way radio applications. (See Photo 1 on page 16.) Previously introduced models cover VHF and UHF bands.^{2,3}

Mounting the antenna inside the rear window avoids the need for cutting a hole through the vehicle's exterior. (See Photo 2 on page 20.)

The same antenna model may be factory-tuned for 800MHz two-way use, including specialized mobile, business, industrial, land transportation and public safety radio. For the most part, company-owned vehicles are equipped with two-way radios. Fleet managers generally opt for the superior performance offered by an antenna mounted on the vehicle rooftop. The DDRR anten-

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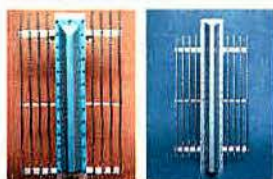
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Superflexible HELIAX Coaxial Cables combine a small bending radius, rugged service, dependability and easy routing even in the tightest places. They flex where you need them to fit, and provide a quality alternative to braided cable.



Andrew Connector Center Pin Packs, in handy protective packages, make it easy to stock and track spares.



2¼ inch HJ12 HELIAX Coaxial Cable is an Andrew exclusive. It gives you performance similar to 3" cable with lower cost and easier handling. It is ideal for 800 MHz applications.

Andrew Solid Copper Grounding Straps and shrink wrap jackets eliminate corrosion and conform to rigorous Mil-Std 188-124A. Having passed U.S. Air Force tests, these assemblies provide no-guesswork protection for your cable.



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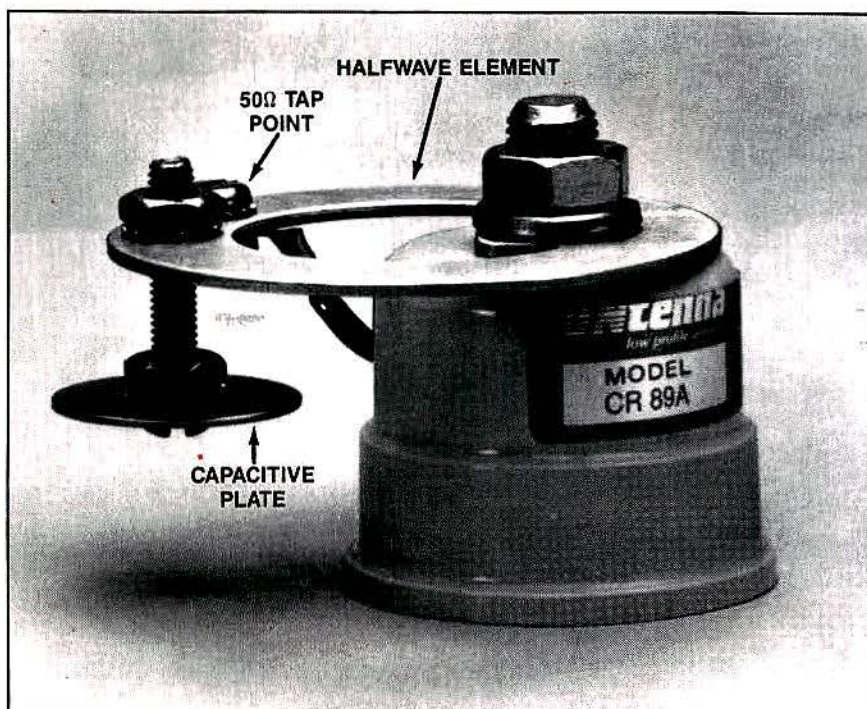


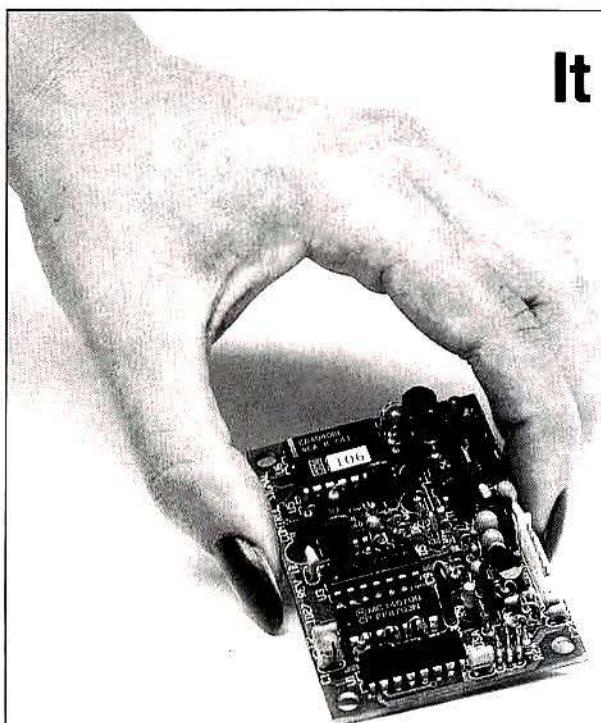
Photo 1. The Untenna directional discontinuity ring radiator (DDRR) antenna uses a halfwave circular element and a capacitive plate for frequency adjustment. The element is tapped at a point with 50Ω impedance.

na may be mounted on upper vehicle body surfaces or concealed underneath the chassis.

Antenna designer and company owner Jim Waldron developed the 800MHz antenna by extrapolation. "It was a normal outgrowth of what I had been doing with other frequencies," he said.

Waldron began his antenna design efforts as an amateur radio enthusiast. "When I got into designing antennas, I made things that work, then went back to analyze why."

VSWR test results are limited. Production models for cellular use are tuned with a cellular telephone RF source. The tap point is fixed. The capacitive plate is adjusted for minimum VSWR at the cellular telephone's operating frequency. No other VSWR measurements to indicate antenna bandwidth have been made. Waldron does caution anyone who measures VSWR at 800MHz frequencies to use a feedline no longer than three feet. Longer lines may obscure true VSWR because of relatively high line losses—0.12dB to



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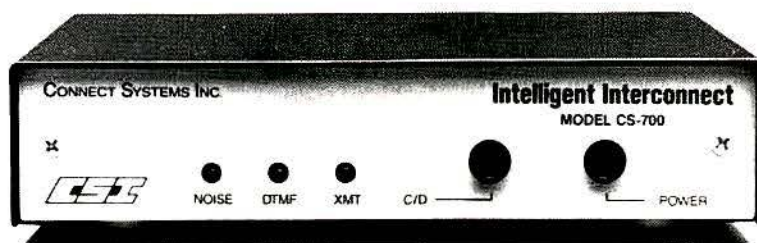
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0.15dB per foot for coaxial cable generally used in mobile installations.

Although many manufacturers strive for broadband antenna performance, Waldron cites his antenna's high Q (narrowband performance) as a reason for its success. "Everyone who has used this product has noticed a remarkable improvement in received audio," Waldron said. "The only explanation I can

give for improved audio is the antenna's high Q, which rejects signals on adjacent channels."

Craig D. Coney, owner of Cal Dak Communications, Spring Valley, CA, reports vehicles equipped with the DDRR deliver stronger signals compared to whip antennas to his repeater site from mountainous terrain near San Diego. He also reports reduced interfer-

Antenna references

Some cellular antennas are thoroughly tested on calibrated antenna test ranges. The tests compare their emission patterns and gain figures, among other characteristics, to standard references. The use of standard references makes tests repeatable and reliable, and their results credible.

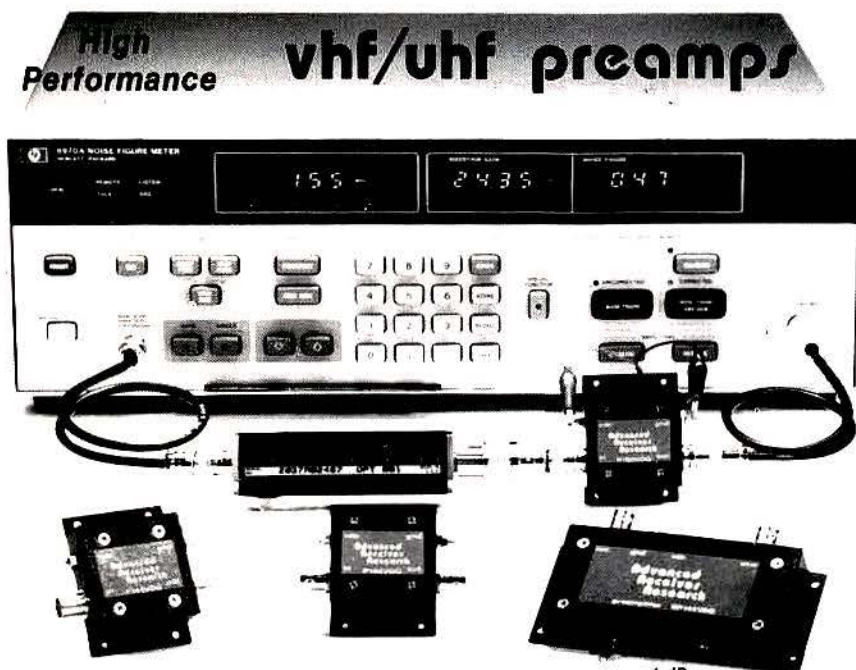
For example, original AT&T Bell Laboratories Advanced Mobile Phone Service (AMPS) specifications for cellular mobile antennas specify 3dB gain compared to a reference halfwave dipole. Nevertheless, you will find some cellular mobile antenna gain figures are compared to quarterwave ground planes, isotropic sources or "the competition." In most cases, you have to ask to learn what reference was used.

The most favorable "3dB" reference as far as the user is concerned is the halfwave dipole; next is the quarterwave ground plane and last is the isotropic source. Where "the competition" as a reference falls is anyone's guess.

Many manufacturers, including the DDRR antenna manufacturer, have not conducted tests with a standard reference antenna. The serpentine array antenna manufacturer has conducted tests with a standard halfwave dipole reference antenna. Both manufacturers rely upon less rigorous measurements, casual observation, testimonials and comparisons with competitors' antennas, as well. Take into consideration the nature of tests and reference antennas upon which performance claims are based.

ence from paging transmitters and 800MHz trunked repeaters.

G.E. Stotesbery, operations manager of Echo Communications, Hugoton, KS, reports improved performance with the antenna mounted on vehicles operating in a sand pit at levels 60 feet and 90 feet below the surrounding plain. The two-way system uses a repeater 35 miles from the pit. The repeater anten-



Receive only

	Freq. Ranges (MHz)	N.F. (dB)	Gain (dB)	Comp. (dBm)	Device Type	Price
P30VD, P35VD, P40VD, P45VD	30-35, 35-40, 40-45, 45-50	<1.3	15	0	DGFET	\$ 44.95
P30VDG, P35VDG, P40VDG, P45VDG	30-35, 35-40, 40-45, 45-50	<0.5	26	+12	GaAsFET	\$109.95
P150VD, P160VD, P170VD	150-160, 160-170, 170-180	<1.5	15	0	DGFET	\$ 44.95
P150VDA, P160VDA, P170VDA	150-160, 160-170, 170-180	<1.1	15	0	DGFET	\$ 56.95
P150VDG, P160VDG, P170VDG	150-160, 160-170, 170-180	<0.5	24	+12	GaAsFET	\$109.95
P450VD, P460VD	450-460, 460-470	<1.8	15	-20	Bipolar	\$ 49.95
P450VDA, P460VDA	450-460, 460-470	<1.2	16	-20	Bipolar	\$ 74.95
P450VDG, P460VDG	450-460, 460-470	<0.5	16	+12	GaAsFET	\$109.95
P800VDG, P830VDG, P860VDG	800-830, 830-860, 860-890	<0.6	19	+12	GaAsFET	\$119.95

Inline (rf switched)

SP30VD, SP35VD, SP40VD, SP45VD	30-35, 35-40, 40-45, 45-50	<1.4	15	0	DGFET	\$ 74.95
SP30VDG, SP35VDG, SP40VDG, SP45VDG	30-35, 35-40, 40-45, 45-50	<0.55	26	+12	GaAsFET	\$139.95
SP150VD, SP160VD, SP170VD	150-160, 160-170, 170-180	<1.6	15	0	DGFET	\$ 74.95
SP150VDA, SP160VDA, SP170VDA	150-160, 160-170, 170-180	<1.2	15	0	DGFET	\$ 88.95
SP150VDG, SP160VDG, SP170VDG	150-160, 160-170, 170-180	<0.55	24	+12	GaAsFET	\$139.95
SP450VD, SP460VD	450-460, 460-470	<1.9	15	-20	Bipolar	\$ 79.95
SP450VDA, SP460VDA	450-460, 460-470	<1.3	16	-20	Bipolar	\$104.95
SP450VDG, SP460VDG	450-460, 460-470	<0.55	16	+12	GaAsFET	\$139.95

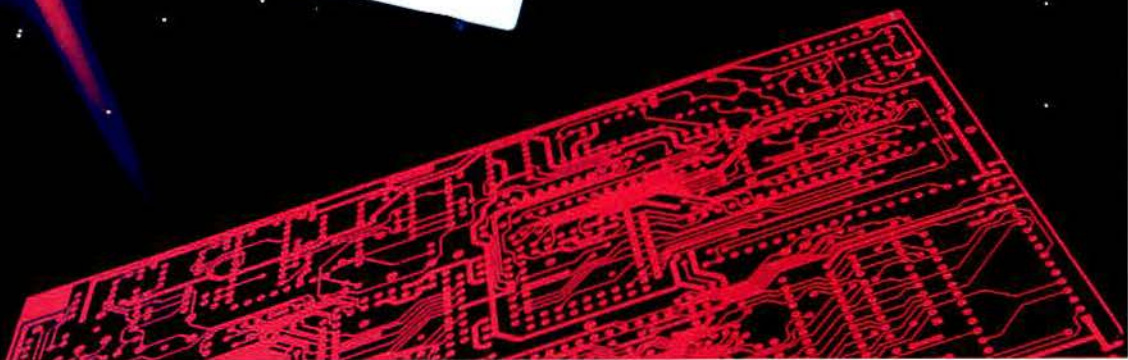
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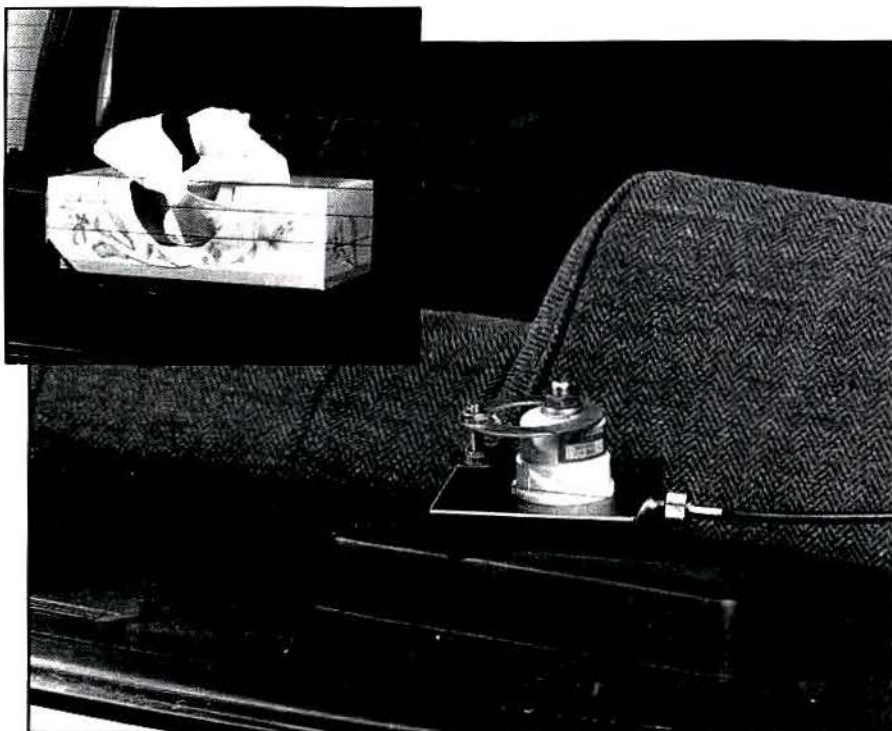


Photo 2. The DDRR antenna may be mounted on an aluminum box as a ground plane in preparation for concealment in the rear window. The inset shows the antenna concealed in a tissue box. The feedline can be concealed or brought through the shelf.

na is 300 feet above ground.

These reports might be used to reason that the 800MHz DDRR antenna emits RF energy at a greater number of vertical angles than most whip antennas. Another explanation might include multiple polarization components besides the predominantly vertical polarization exhibited by whip antennas. But Waldron is quick to distance himself from any claims: "No emission pattern, gain or polarization tests have been conducted for the 800MHz DDRR antenna."

References

1. *Electronics*, January 1963, includes a description of the directional discontinuity ring radiator antenna. *QST*, July 1972 presents a mathematical analysis of the antenna.
2. Bishop, Don, "Undercover 'Antenna' Goes Underneath Unmarked Cars," *Mobile Radio Technology*, pp. 20-21, September 1986.
3. "Low Profile Antenna Uses Top Loading. Maintains Vertical Polarization," *Mobile Radio Technology*, pp. 58-60, May 1984.



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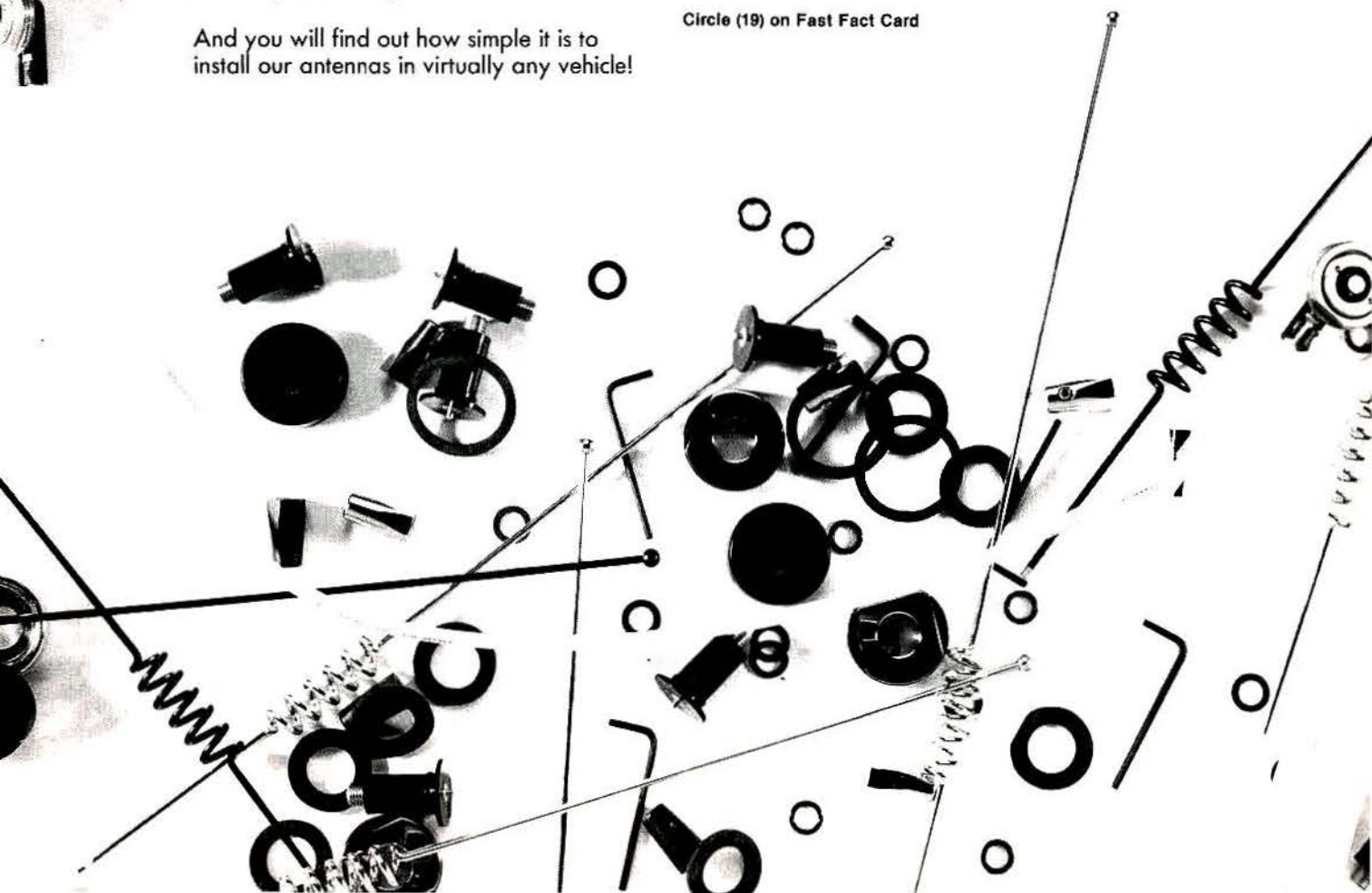
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Cellular test equipment roundup

Nine manufacturers offer full-featured equipment for testing cellular mobile and portable telephones. Units are pictured below. A table of features and reader service numbers for more information is on page 24.



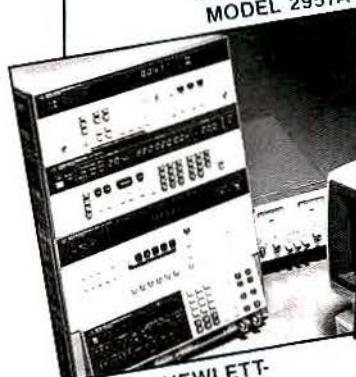
MARCONI
INSTRUMENTS
MODEL 2957A



ZK CELLTEST
ZK-S1



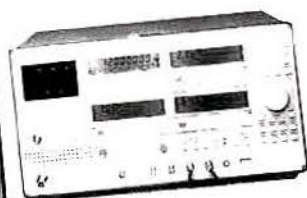
CT SYSTEMS
MODEL 2500



HEWLETT-
PACKARD
HP8957S



IFR SYSTEMS
FM/AM-1200S
W/OPT. 15



ROHDE &
SCHWARZ
CMT



ZK CELLTEST
ZK-SAM



MOTOROLA
R-2008D

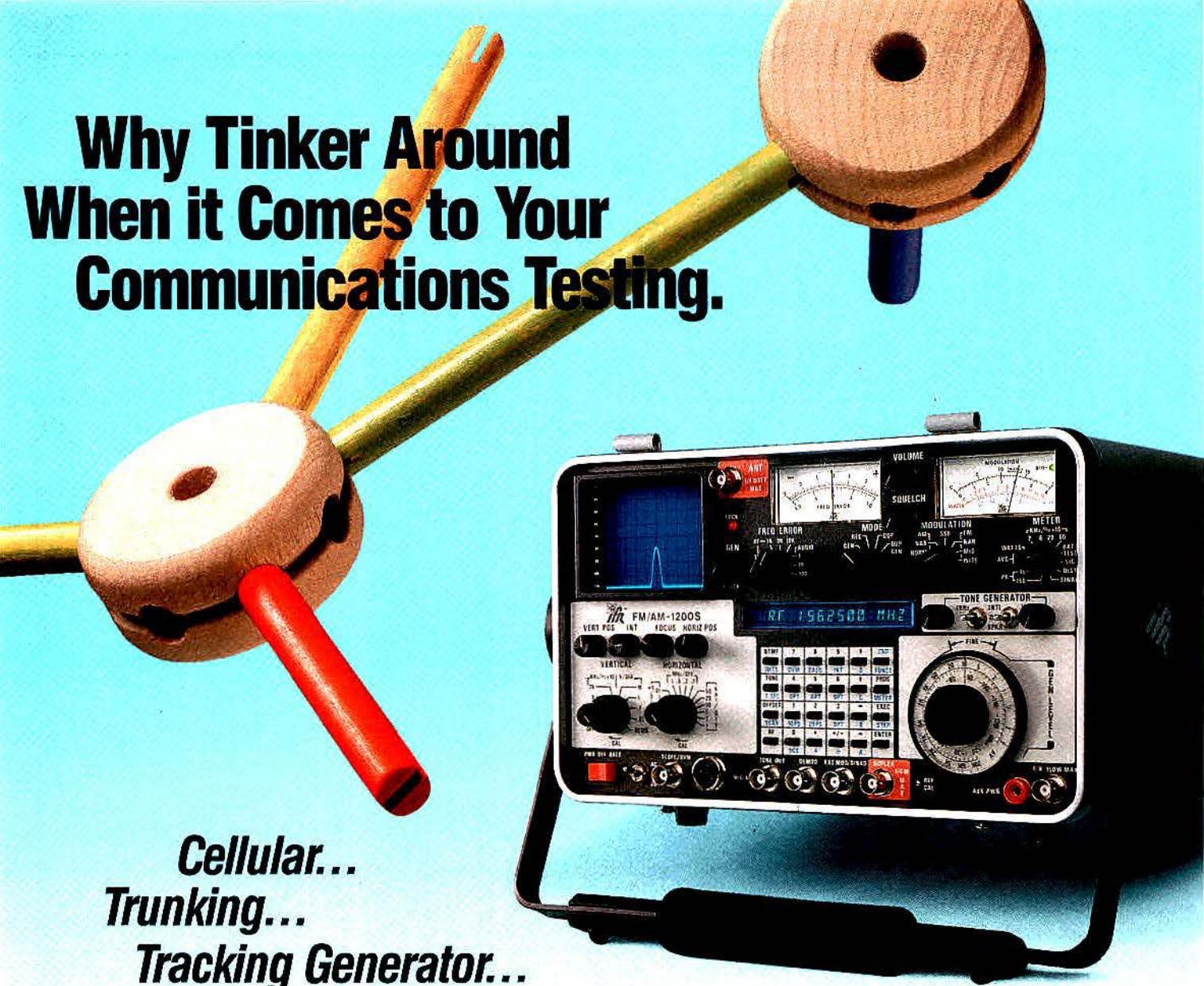


IFR SYSTEMS
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Where else can you get all this capability in one communications test set? No where! Compare and you'll agree...the FM/AM-1200S *is* the logical choice.

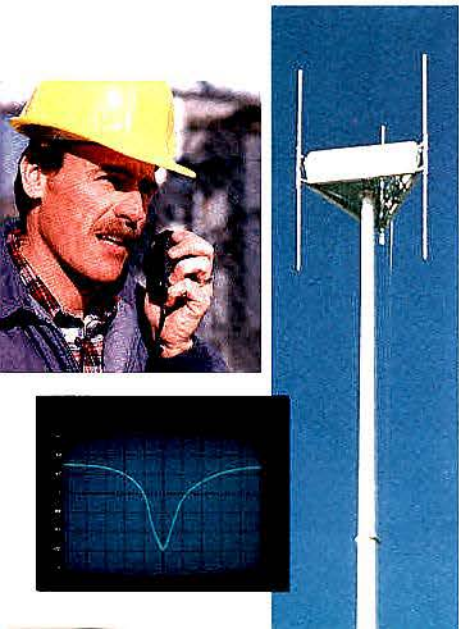
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Cellular test equipment roundup

Manufacturer & Model Number	Compatibility	Display Type	Power Measurement Range	Size (HxWxD)	Weight (pounds)	Stand-alone?	Call Processing?	Automated Test Function?	Printout Interface?	Menu-Driven?	Software Upgradeable?	Displays Serial in Decimals?	Suggested Retail Price	Reader Service Number
CT Systems Model 2500	AMPS	VFD ¹	0W-110W	10" x 6.5" x 15.5"	15	Y	Y	Y	Y	Y	Y	Y	\$5,995	200
Hewlett Packard HP8957S	AMPS TACS NMT	CRT	200mW-20W	36" x 17" x 22"	175	Y	Y	Y	Y	Y	Y	Y	\$45,000-\$65,000	201
IFR Systems FM/AM-1200S w/Opt. 15	AMPS	VFD CRT	0W-150W	7.3" x 13.1" x 17.5"	43	Y	Y	Y	Y	Y	Y	Y	\$9,790	202
FM/AM-1500 w/Opt. 08	AMPS	CRT	0W-150w	9" x 12.5" x 19.5"	46	Y	Y	Y	Y	Y	Y	Y	\$17,995	203
Japan Radio NJZ 900	AMPS	LCD	4mW-4W	7" x 12" x 13"	22	Y	Y	Y	Y	N	Y	Y	\$7,995	204
Marconi Instruments Model 2957A	AMPS	CRT	0.5mW-100W	7.75" x 13.6" x 18.1"	34	Y	Y	Y	Y	Y	Y	Y	\$11,895	205
Motorola R-2008D	AMPS	CRT	0W-125W	8.25" x 15.5" x 20"	35.5	Y	Y	Y	Y	Y	Y	Y	\$21,590	206
Rohde & Schwarz CMT	AMPS TACS NMT	LCD	5mW-50W	16.5" x 8.7" x 13.4"	42	Y	Y	Y	Y	N	Y	N	\$20,000	207
Schlumberger Instruments 4040/4922	AMPS	CRT	0W-50W	17.4" x 5.3" x 16.4"	64	Y	Y	Y	Y	Y	Y	Y	\$31,955	208
4031 (Cell. Opt.)	AMPS	CRT	0-50W	9" x 14.7" x 19.1"	41	Y	Y	Y	Y	Y	Y	Y	\$18,400	209
ZK Celltest ZK-1200A	AMPS TACS	LCD	See IFR 1200	1.5" x 16" x 10"	3	N ²	Y	Y	Y	Y	Y	Y	\$2,495	210
ZK-4	AMPS TACS	CRT	Depends on monitor	1.5" x 16" x 10"	3	N ³	N	Y	Y	Y	Y	Y	\$1,695	211
ZK-M1	AMPS TACS	Marconi 2955/2957	0.5mW-100W	1.5" x 16" x 10"	3	N ⁴	N	Y	Y	Y	Y	Y	\$2,695	212
ZK-SAM	AMPS TACS	LCD	N/A	1.5" x 4.75" x 6"	0.5	N ⁵	N	Y	Y	Y	Y	N	\$1,295-\$2,495	213
ZK-S1	AMPS TACS	CRT or LCD	N/A	1.5" x 9.5" x 6"	1	Y	N	Y	Y	Y	Y	N	\$10,500-\$14,500	214

1. Vacuum Florescent Display.
2. Requires IFR 1200.
3. Requires a service monitor.
4. Requires Marconi 2955/2957.
5. Must be used with mobile phone.



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Controlling interference at communications sites

Part 2—Intermod and noise are like a poison that spreads slowly through a poorly managed radio communications site. Eventually, only those users who can tolerate degraded service remain, and growth stops.

By Al Dolgosh and
Ron Jakubowski

Uncontrolled site growth can reduce communications efficiency to zero. Without a coordinated effort on the part of the site manager and the users, two problems will cause the site to "grow deaf," slowly, gradually, as more users are added to the site. The "deafness" is caused by intermodulation products and by an elevated noise floor. Both phenomena affect the ability of the site equipment to receive signals from mobile units and portable transceivers.

Intermod

An intermodulation product (intermod) is a signal created when two or more transmitter frequencies are mixed with one another unintentionally. Mixing can occur in transmitter circuitry, in receiver circuitry and elsewhere.

The apparent effect is the same: one or more low-level signals strong enough to interfere with desired signals and prevent reception. Sometimes the intermod falls on unused frequencies. Sometimes it falls on a channel in use or near enough to the channel to cause interference.

Mathematics can be used to calculate intermod that may result from operations on frequencies in use at a site. Normally produced by a computerized analysis, the "intermod study" is helpful in several ways.

If the study is conducted as one or more new frequencies are under con-

sideration for future use at an existing site, the study may reveal which frequencies are more likely to produce harmful intermod and which are not.

If the study is conducted as part of an investigation into an interference problem, it may help in identifying transmitters that play a role in generating the intermod.

Site management series

Part 1, "Structure Your Site For 'Technical' Success" appears in the January issue. It includes a checklist of the major technical and operational aspects of site management.

'Intermod generators'

Intermod can be generated by any non-linear device or circuit.

The most common place for intermod to be generated is in an FM transmitter's power amplifier. The amplifier does not need to preserve waveform integrity; the waveform is restored by the tuned output circuit. Thus, the amplifier is operated in an efficient but non-linear mode, Class C.

In contrast, amplifiers for amplitude companded single-sideband (ACSSB) must be operated in a linear mode. Such amplifiers normally do not act as mixers.

Generally, solid-state amplifiers are better "mixers" than their electron tube counterparts, a fact that may explain why intermod may appear suddenly when older equipment is replaced.

A mix occurs when RF energy from one transmitter (Tx 1) finds its way down the transmission line and into the final amplifier of another transmitter (Tx 2). (See Figure 1 on page 28.) It mixes in the final amplifier with the prefiltered second-harmonic energy of Tx 2 to produce another in-band signal, a third-order intermod product.

The reverse mix may occur in Tx 1's final amplifier, producing another intermod frequency.

Once discovered, mixes generated in the transmitters' final amplifiers are relatively simple to eliminate. The cure is to increase the isolation between the offending transmitters.

Isolation may be increased by enlarging the space between the antennas.

But usually, an "isolator" is placed at each transmitter's output. An isolator is a one-way path for RF energy. It is installed to allow the transmitted signal to pass to the antenna with negligible loss while it blocks signals traveling in the reverse direction, such as power from other transmitters coupling into nearby antennas. The increased isolation provided by an isolator usually is enough to eliminate intermod generated in the transmitters' final amplifiers.

Receiver intermod

Intermod may be generated in the front-end of a receiver.

A large amount of RF energy from transmitters at the site can generate a bias voltage in the receiver sufficient enough to place the receiver's transistorized RF amplifier into a non-linear state. In that mode, the transistor amplifier acts as a mixer and creates unwanted frequencies—intermod.

Dolgosh is director of technical marketing, and Jakubowski is systems engineering manager at Antenna Specialists, Cleveland.

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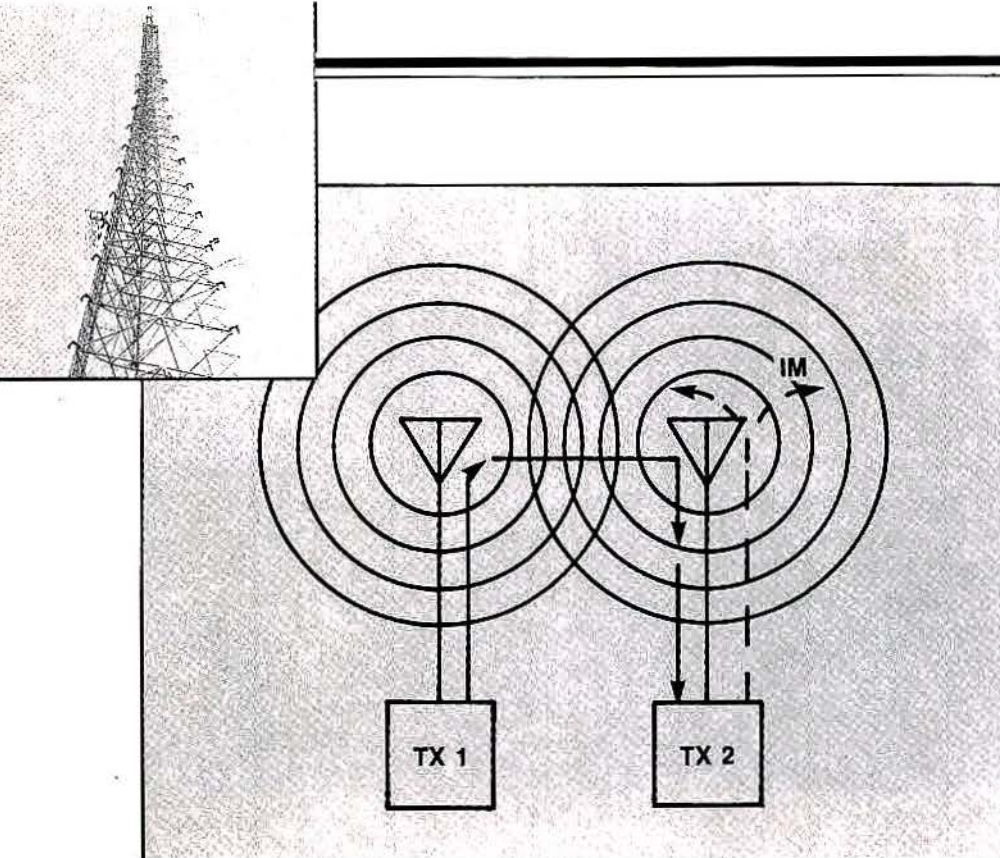


Figure 1. A mix occurs when RF energy from one transmitter (TX 1) finds its way down the transmission line and into the final amplifier of another transmitter (Tx 2). Within the Tx 2 final amplifier, the RF energy mixes with prefiltered second-harmonic energy to produce another in-band signal—a third-order intermod product. The reverse mix may occur in TX 1's final amplifier, producing yet another intermod frequency.

Intermod sources

- ☐ **Transmitter**—The transmitted signal from one transmitter mixes with prefiltered harmonic energy inside another transmitter's non-linear final amplifier.
- ☐ **Receiver**—Transmitted RF energy generates a voltage in a nearby receiver's RF amplifier, biasing its transistor into a non-linear state that allows it to act as a mixer. The 'mixer' generates unwanted intermodulation products.
- ☐ **Hardware**—Dissimilar or corroded metal connections form non-linear electrical junctions that act as mixers. In the presence of powerful transmitters, these 'mixers' generate intermod.
- ☐ **Antenna**—Nut-and-bolt fasteners may loosen or corrode, forming non-linear electrical junctions.

Intermod solutions

- ☐ **Transmitters**—Increase the isolation between the transmitters. Options include increasing the antenna separation and installing isolators at the transmitter outputs. A combiner may be used to feed all the transmitters to one antenna; if so, isolators should be installed at the transmitter outputs.
- ☐ **Receivers**—Block high levels of transmitter energy from entering the receiver. Options include notch filters and bandpass filters in-line with the receiving antenna.
- ☐ **Hardware**—Use non-corrosive hardware, keep fasteners tightened, follow proper grounding and bonding guidelines and remove all metallic debris from the site.
- ☐ **Antenna**—Use antennas with welded construction instead of nut-and-bolt fasteners.

One solution is to insert filters into the receive antenna transmission line. The filters have deep attenuation, or notches, at each transmitter frequency.

When another transmitter is added to the site, another notch filter must be added to the receiver transmission line.

The use of notch filters is more common with VHF highband equipment because frequency allocations at VHF highband are less organized than those at higher frequencies.

In a properly planned site with 450MHz and 800MHz equipment, frequencies may be grouped together and combined. These actions yield a proper balance of antenna isolation. Moreover, receiver bandpass filters can be employed to provide a more flexible solution to interference and noise problems.

'Hardware intermod'

The third, and most insidious, source of intermod is *hardware*.

The entire site—the tower, guy wires, antennas, clamps and obstruction lighting hardware—is saturated by high-level RF from the antennas. Any loose or moving hardware can cause broadband noise. Any corroded connections, tower joints or clamps can form semiconductors that may generate harmful intermod.

Because the antenna system is exposed to a changing external environment, the degree of semiconductivity can vary with moisture or temperature. Changing semiconductivity causes intermittent problems, whose severity may change, too.

It is of the utmost importance that high-quality, non-corrosive or corrosion-resistant hardware be used everywhere on the site. Proper grounding and bonding techniques must be followed.

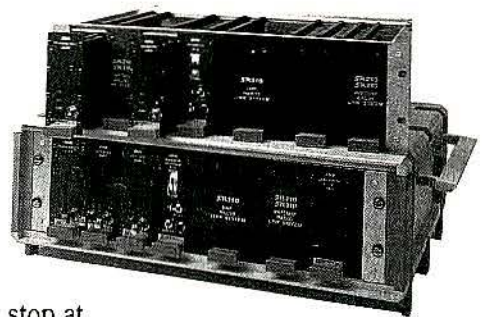
'Antenna intermod'

The antenna itself can be a source of noise or intermod. To reduce noise and intermod, properly designed, high-quality base station antennas make extensive use of welded construction instead of nut-and-bolt fasteners. Aluminum and stainless steel are used on exposed areas. The use of non-corrosive materials for internal assemblies is not overlooked despite their being out of view. Once again, the goal is to elimi-

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DX RADIO SYSTEMS

Setting The Pace In Radio Science

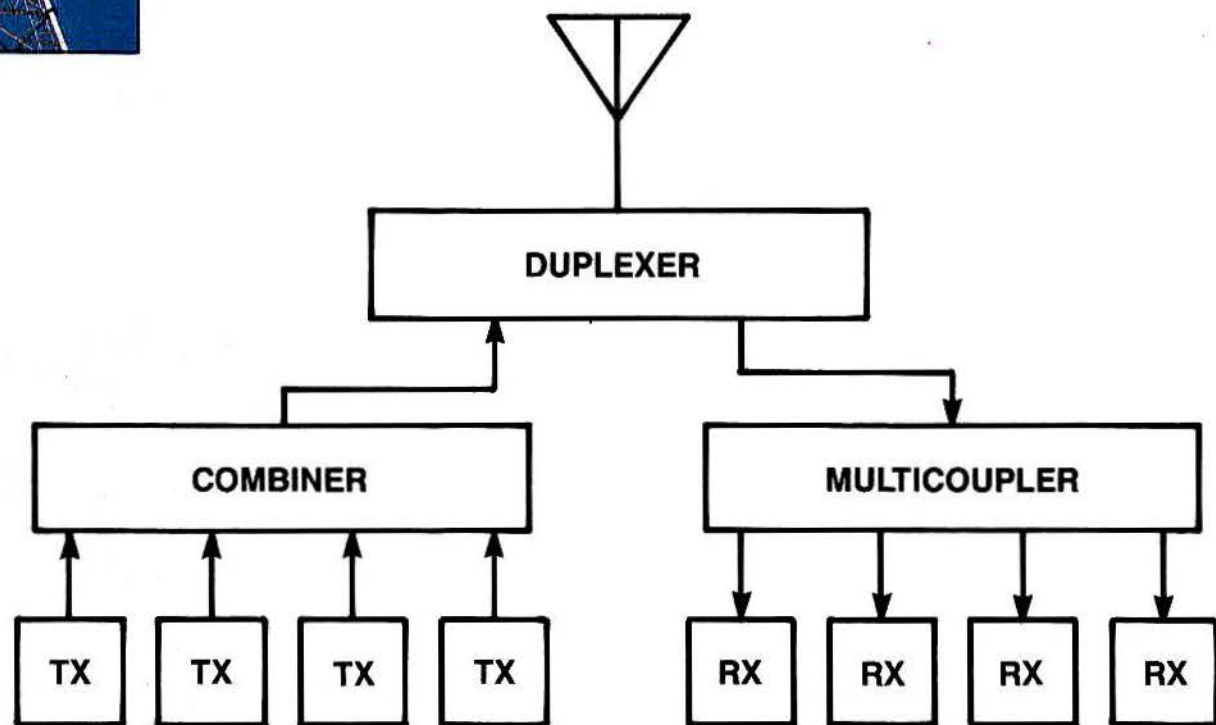


Figure 2. To control intermod and noise, use a system that places all transmitters and receivers on a single antenna.

With a combiner in the system, each transmitter's output passes through a dual-junction isolator and a high-Q cavity. A properly designed combining system exhibits low insertion loss, prevents

intermod, filters broadband transmitter noise and allows a site to be expanded in an orderly manner.

Moreover, the combination of a good receiver multicoupler and low-noise amplifier actually improves the receiver noise figure and overall system performance.

nate loose or corroded semiconducting connections.

Fixing what's wrong

To fix noise and intermod problems that may result if a site is allowed to grow unsupervised is extremely difficult and expensive compared to preventing them. A site manager should supervise the site from the time the tower base is excavated, or even before, so construction techniques may be influenced and guided before "surprises" that require expensive corrections manifest themselves.

A hidden evil at most jointly occupied sites derives from the "my system, your system" point of view in which each site user believes a stand-alone system is necessary.

With repeater systems, many duplex-

ers provide only cross-notch isolation, which keeps only *that* system free from broadband noise generated by its own transmitter. The duplexer does little or nothing to reduce broadband transmitter noise generated on other receive frequencies. Thus, the resulting noise floor at the site becomes high enough to mask weak signals.

We have heard from site managers who say, "It used to be a good site 10 years ago but something has happened to it. Maybe the trees and foliage grew up or . . . who knows?" They do not realize that the noise floor has been raised far above the ambient level by an uncontrolled addition of transmitters to the location.

The solution is a transmitter combining system. (See Figure 2 above.) Transmitter combining and receiver mul-

ticoupling should be considered as the *first* step to efficient site management, not merely an alternative.

With a combiner in the system, each transmitter's output passes through a dual-junction isolator and a high-Q cavity. A properly designed combining system exhibits low insertion loss, prevents intermod, filters broadband transmitter noise and allows a site to be expanded in an orderly manner. Moreover, the combination of a good receiver multicoupler and low-noise amplifier actually improves the receiver noise figure and the system's overall performance.

The next installment in this series will discuss the effect upon system performance caused by mounting antennas to the side of a tower.



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How to design and use radiating cable systems

Part 2—With proper planning, you can design radiating cable systems for nearly any environment. Calculations help you to determine design constraints. Included are installation suggestions and cable selection methods.

By Udo Bode

Cable series

Part 1 of this series, "Use Coaxial Cable to Communicate Where Antennas Cannot Go," was printed in the April 1989 issue.

The first article introduced slotted coaxial cable as a solution to provide transmission and reception of radio signals in environments such as railways, mines, ships and large buildings where traditional antennas may be impractical.

Two kinds of cables can be used as longitudinal antennas: radiating coaxial cable and "leaky" coaxial cable.

Radiating cable has groups of slots in the outer conductor at half-wavelength intervals, slots that act as radiators within a narrow frequency band.

All other known designs are leaky coaxial cables that couple the internal coaxial transverse electromagnetic (TEM) propagation mode one way or another to an external surface wave. Leaky coaxial cables have broadband characteristics.

Nevertheless, both kinds, slotted and leaky, commonly are called radiating cable. The following discussion provides installation suggestions for slotted and leaky cable, and describes a method for selecting the proper cable

for a given installation. One type of slotted cable has a continuous, lengthwise slot in the outer conductor. Another design, which is patented, has coupling slots at irregular distances along the length of the cable. (See Figure 1 below.)

- *Continuous slot*—Cables with a continuous longitudinal slot usually have a stamped-copper outer conductor that covers about 75% of the inner cable core. A bead near the slot strengthens the jacket. When recommended mounts are used, the slot points away from the support.

Fire-resistant, halogen-free jackets are available for continuous longitudinal

slot cables, but internal losses are greater with these as compared to cables with standard jackets.

One type of continuous-slot cable has a solid dielectric; another has a cellular polyethylene dielectric.

- *Random slot*—Pairs of slots in randomly slotted cables are spaced about 20m apart. The openings amount to only about 0.2% of the outer conductor's surface area. Irregular slot spacing reduces the effect the openings have on return loss.

With the random-slot cable, optional fire-resistant jacketing causes no significant increase of internal loss.

Random-slot cable overcomes an

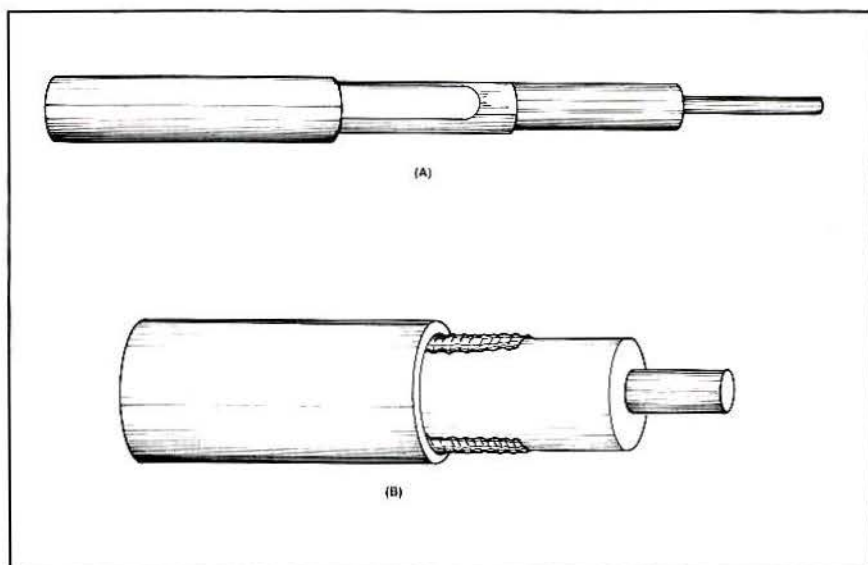


Figure 1. Most radiating cables are 'leaky' cables that support a surface wave. Cable (A) has randomly distributed groups of coupling slots designed to reduce internal attenuation and environmental effects

such as contamination and water migration. But if at least one group of slots is not positioned in each room to be served, it is better to use continuous-slot (B) cable tailored to the application.

Bode is director of engineering at Cablewave Systems, North Haven, CT, a division of Radio Frequency Systems, a member company of the International Radio Frequency Systems Group.

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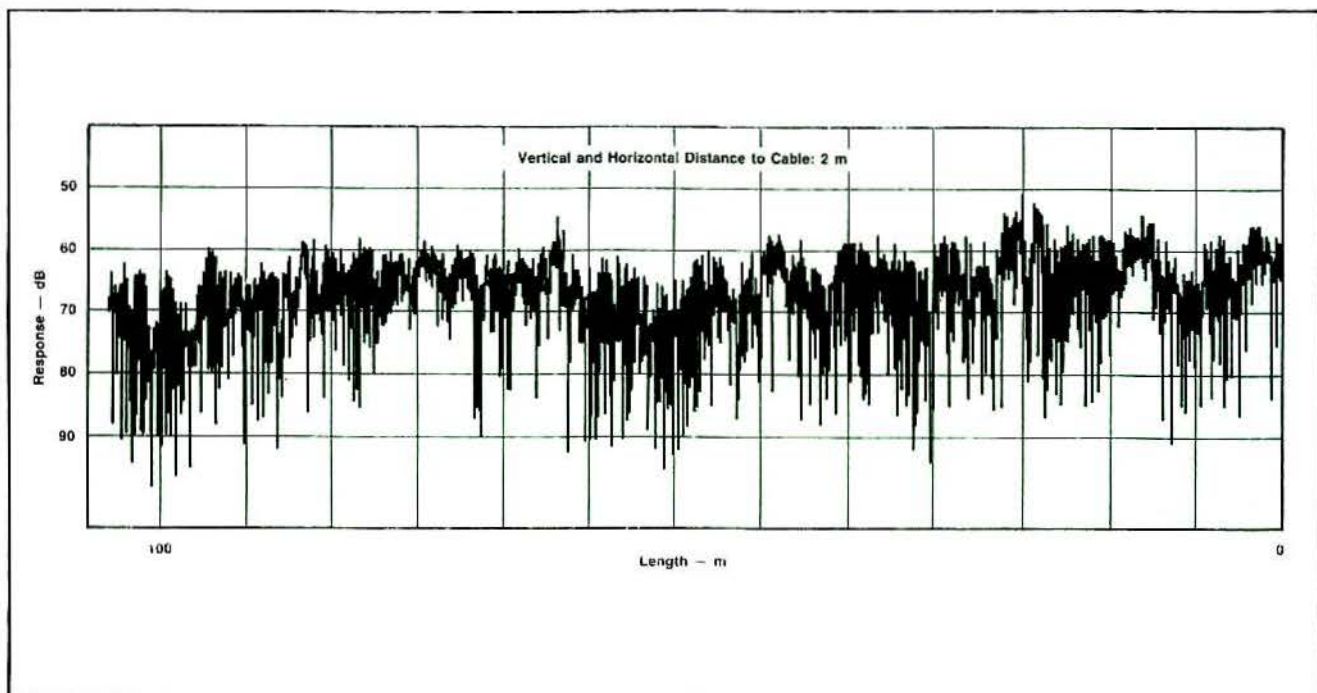


Figure 2. The coupling slot configuration and spacing can be customized for optimum coupling loss and return loss in a specific environment and for a specific frequency band. In this example,

the slots in Cablewave's 50!! ALF-9/23 cable were customized for optimum coupling performance at cellular mobile telephone frequencies.

environmental problem in road tunnels: the accumulation of sprayed salt deposits. With continuous-slot cable, salt deposits increase the insertion loss significantly. The small, irregularly spaced slots in the random-slot cable are much less sensitive to salt deposits. Random-slot cable tested with saturated salt solution applied in the immediate vicinity of the slots have shown only a 2.5% increase in insertion loss at 450MHz.

Coupling slot configuration and spacing can be customized for optimum coupling loss and return loss performance for a given installation and for a specific radio service's operating frequency, such as cellular mobile telephone. (See Figure 2 above.)

Cable selection

Use continuous-slot cable when the distance between the receiving antenna and the cable is short.

For installations inside buildings (such as in an elevator shaft) random-slot cable is unsuitable if at least one pair of slots cannot be placed in each room. Without a pair of slots in each room, some areas will be served poorly and may not have service. The alterna-

tive is to use continuous-slot cable.

Because environmental factors affect the cable's transmission properties, use mounting clips and spacing cones to mount the cable at a distance from decks and walls.

Special clips and eyelet screws attach the cable to a suspension wire. A bead in the protective cable jacket indicates how the slot will be oriented in relation to the suspension wire.

Large installations

Feed the cable at its center to serve large installations. (See Figure 3 on page 36.) Center-feeding allows the greatest length of cable to be used before booster amplifiers are necessary.

The fixed station routes outgoing cables through a power splitter. Additionally, splitters serve connecting branches, when necessary.

Simple T-fittings can be used as splitters in less-critical applications. The insertion loss amounts to 5dB, and the outgoing cables are not matched to the feeding cable impedance. For the feeding cable, a T-junction represents a load with a 9.5dB return loss.

If you need to avoid the drawback of the T-fitting's return loss, use matched

power splitters. The feed cable impedance is matched by resistors in the T-adapter; the loss is 6dB.

To minimize reflected power, properly terminate the ends of the cable run. Depending on the fixed station transmitter power, fixed terminations rated at 1W to 25W are adequate.

When distances are not too great, RG213/U (50 Ω) or RG-11A/U (75 Ω) coaxial cable provides a flexible path for connecting the slotted cable to the fixed station. RG-type coaxial cable can be used to connect sections of slotted cable together when a physical obstacle that must be bridged cannot be circumvented by the slotted cable. For bridging large distances, 50 Ω or 75 Ω FCC-type or FLC-type cable is recommended.

Cable system calculations

Several key pieces of information must be known before a slotted or leaky cable design can be proposed that will provide clear transmission from the fixed station to mobile receivers and reliable reception at the fixed station from mobile transmitters:

- A map of the space to be served.
- The nature of the information to be transmitted and received.

BUILT TO GO THE DISTANCE

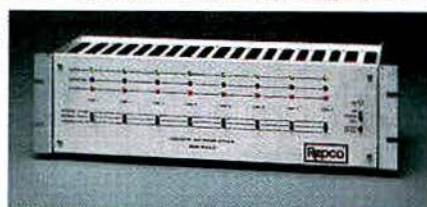


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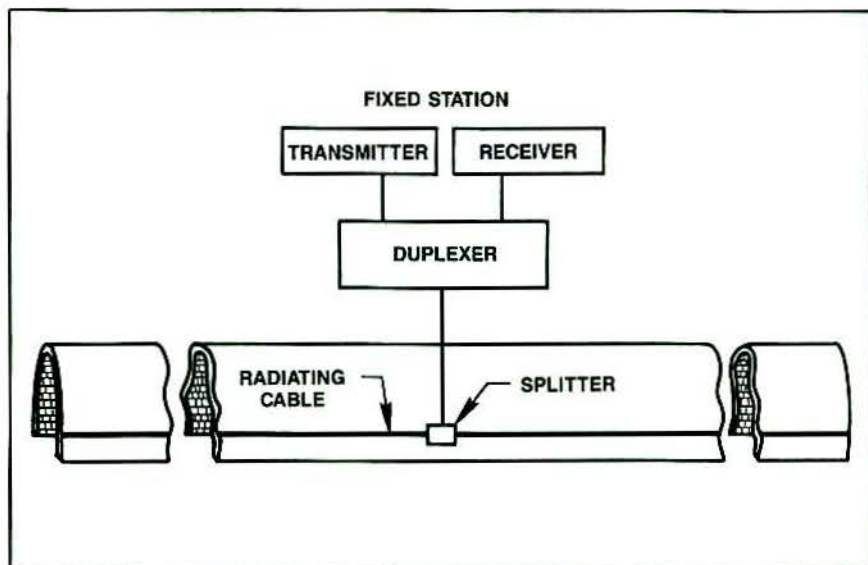


Figure 3. Slotted or leaky cable in a tunnel installation should be fed from the center (A) to reduce the number of repeaters necessary to serve the system. In an office building (B), the transmitter feeds each floor through a coupler.

- Frequencies.
- Distances between the cable and mobile antennas.
- Fixed station output power.
- Fixed station receiver sensitivity.
- Mobile station output power.
- Mobile station receiver sensitivity.
- Mobile station antenna type and gain.
- Corresponding specifications for portable transceivers.
- Impedances.
- Installation conditions.

The maximum acceptable loss of the internal transmission system (a_{max}) is the loss between the fixed station output and the ends of the slotted or leaky cable when the minimum acceptable signal level is obtained in the vicinity of the cable ends.

The maximum cable run that can be served without using an amplifier is L_{max} , and the following relations hold:

$$a_{max} = a_s + a_c(50) + a_{c,N} + a_z \quad \text{in dB}$$

$$a_s = p_t - p_r \quad \text{in dB}$$

where:

a_s = allowable system loss in dB

p_t = transmitter power in dBm

p_r = receiver sensitivity in dBm

$a_c(50)$ = coupling loss for 50% reception probability in dB

$a_{c,N}$ = sum of corrections added to coupling loss in dB

a_z = insertion loss of connecting cable in dB

Also true are the relationships:

$$L_{max} = a_{max}/a \quad \text{in km (end-fed system)}$$

$$L_{max} = 2(a_{max} + a_v)/a \quad \text{in km (center fed system)}$$

where:

a_v = insertion loss of splitter in dB

a = cable attenuation in dB/km

The following example illustrates the necessary calculations:

Let us determine the length of highway tunnel that can be served adequately without an amplifier if the following 50Ω equipment is available and model ALF 9/23 slotted cable is used. The highest operating frequency is 900MHz.

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 Rx sensitivity 1 μ V (-107dBm)
 Antenna gain -3dB
 Maximum antenna distance
 to cable 4m

The receiver probability is 95%.

The allowable system loss, a_s , is calculated as follows:

Fixed-to-mobile station:

$$a_s = 40 - (-107) \text{ dB} = 147\text{dB}$$

Mobile-to-fixed station:

$$a_s = 30 - (-113) \text{ dB} = 143\text{dB}$$

The smaller value of both, shown here to be 143dB, must be used for further calculations:

The coupling loss for 50% receive

probability is:

$$a_c(50) = -70\text{dB}$$

The system corrections add up to the following ($a_{c,N}$):

Receive probability of 95% -10dB
 Antenna gain -3dB
 Antenna/cable distance factor -3dB
 Safety margin for
 environmental conditions -15dB

$$a_{c,N} = -31\text{dB}$$

The maximum allowable transmission line attenuation now can be calculated with the figures provided above to determine the following:

$$a_{max} = a_s + a_c(50) + a_{c,N} + a_z$$

$$a_{max} = 143 + (-70) + (-31) + 0$$

$$a_{max} = 42\text{dB}$$

The length of tunnel that can be served under the above assumptions by an ALF 9/23 cable at 900MHz is:

For an end-fed system:

$$L_{max} = a_{max}/a$$

$$a = \text{cable attenuation/length } (a = 47\text{dB/km in this case})$$

$$L_{max} = 42/47$$

$$L_{max} = 0.89\text{km}$$

For a center-fed system:

$$L_{max} = 2(a_{max} + a_v)/a$$

$$a_v = \text{insertion loss of the matched power splitter } (a_v = -6\text{dB})$$

$$L_{max} = 2(42 - 6)/47$$

$$L_{max} = 1.53\text{km}$$

This calculation shows that, without a repeater, a center-fed system can cover more length than an end-fed system. If the environment is relatively clean, the safety margin of 15dB can be decreased and the allowable cable length will increase accordingly.

This example is based on hypothetical data. Nevertheless, the calculation



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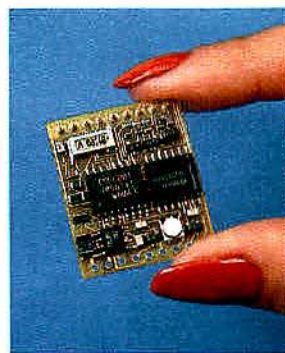
Digital PSK modulation is employed in combination with powerful error detection and correction protocols to provide superior accuracy and reliability. Coded's automatic transmitter identification encoders and decoders typically exceed 99.99% signaling reliability at signal-to-noise ratios too low to support effective voice communications.

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miniature encoders are designed to fit the smallest portable and mobile equipment and are easily installed. Coded's status display system, shown above, provides dispatchers with an efficient cost effective solution for fleet status monitoring. Our system controllers are designed to interface with complex CAD systems and can accommodate the largest public safety fleets.

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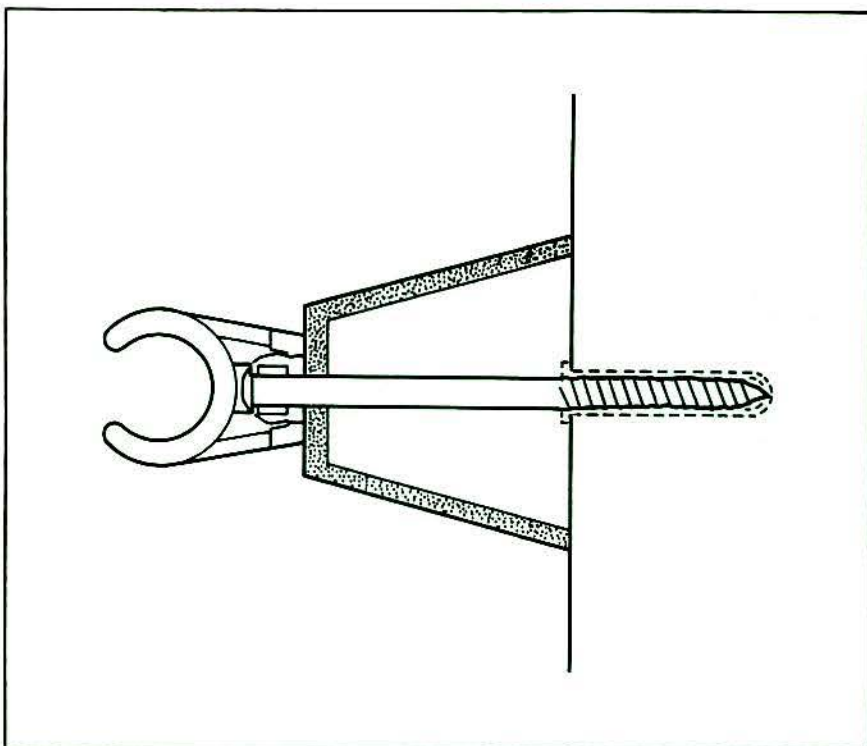


Figure 4: Mount the cable to the wall with special hardware that maintains the distance of the cable to the wall. Other accessories are available to meet specific requirements.

method shown, together with technical support from the manufacturer, allows system designs to be made without difficulty.

It might be necessary to use two types of cable in one system to achieve optimum performance. For example, random-slot cable might be used to keep insertion loss at a minimum; continuous-slot cable might be used for one or more short branches that cannot be served adequately by random-slot cable.

Installation

Accessories make installation easy even in the most demanding environments. (See Figure 4 at the left.) Included are connectors that install without special tools; straight adapters that connect two cable sections together; termination loads that provide a match to the end of the cable; and "tees" and power splitters for sending power to two transmission lines.



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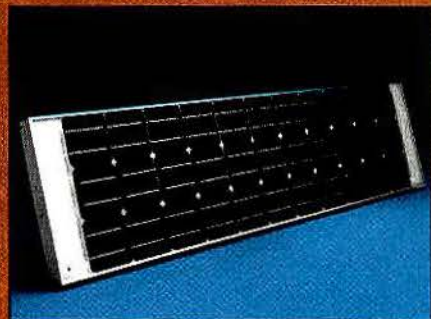
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Performance standards detail test procedures

Performance standards from the National Institute of Justice offer detailed procedures for equipment testing and specifications for equipment procurement. Here's how to put technical standards to work.

By Lawrence K. Eliason

Radio communications technicians and managers use equipment performance standards to conduct equipment tests and to simplify the process of writing technical specifications for equipment procurement.

Manufacturers find performance standards helpful in learning what is ex-

pected of equipment for each particular application.

Many readers use standards developed by the National Institute of Justice (NIJ) Technology Assessment Program. The program focuses on the criminal justice community's needs. Nevertheless, the research applies equally to the private sector, including land mobile radio equipment for business and industrial use.

Mobile Radio Technology magazine prints feature articles written by researchers who develop standards and other documents. The editors adapt

government publications to prepare the articles.

MRT publicizes new documents in the monthly "Literature" column.

Program background

"The technology assessment program has three functional elements," according to Lester D. Shubin, director of science and technology at NIJ. They are:

- **Advisory Council**—Practitioners from federal, state and local criminal justice agencies help to establish research priorities. "They also help to select equipment to be tested in accordance with the performance standards," Shubin said.

- **Information Center**—The center administers equipment testing conducted by independent laboratories and disseminates the program's publications.

"Staff members respond to individual requests for information phoned to the center's toll-free hotline," Shubin said.

The center also handles requests entered via Search System, an on-line database. "The database includes the full text of all NIJ documents," he said. "The system searches for all documents' full texts, including standards, guides, reports and consumer product lists."

- **Law Enforcement Standards Laboratory**—George Lieberman manages the laboratory's communication systems program, which holds the greatest interest for technicians and engineers. Until Dec. 31, Marshall J. Treddo was the manager.

The entire technology assessment program includes weapons and protective equipment, as well as forensic science, vehicles, emergency warning

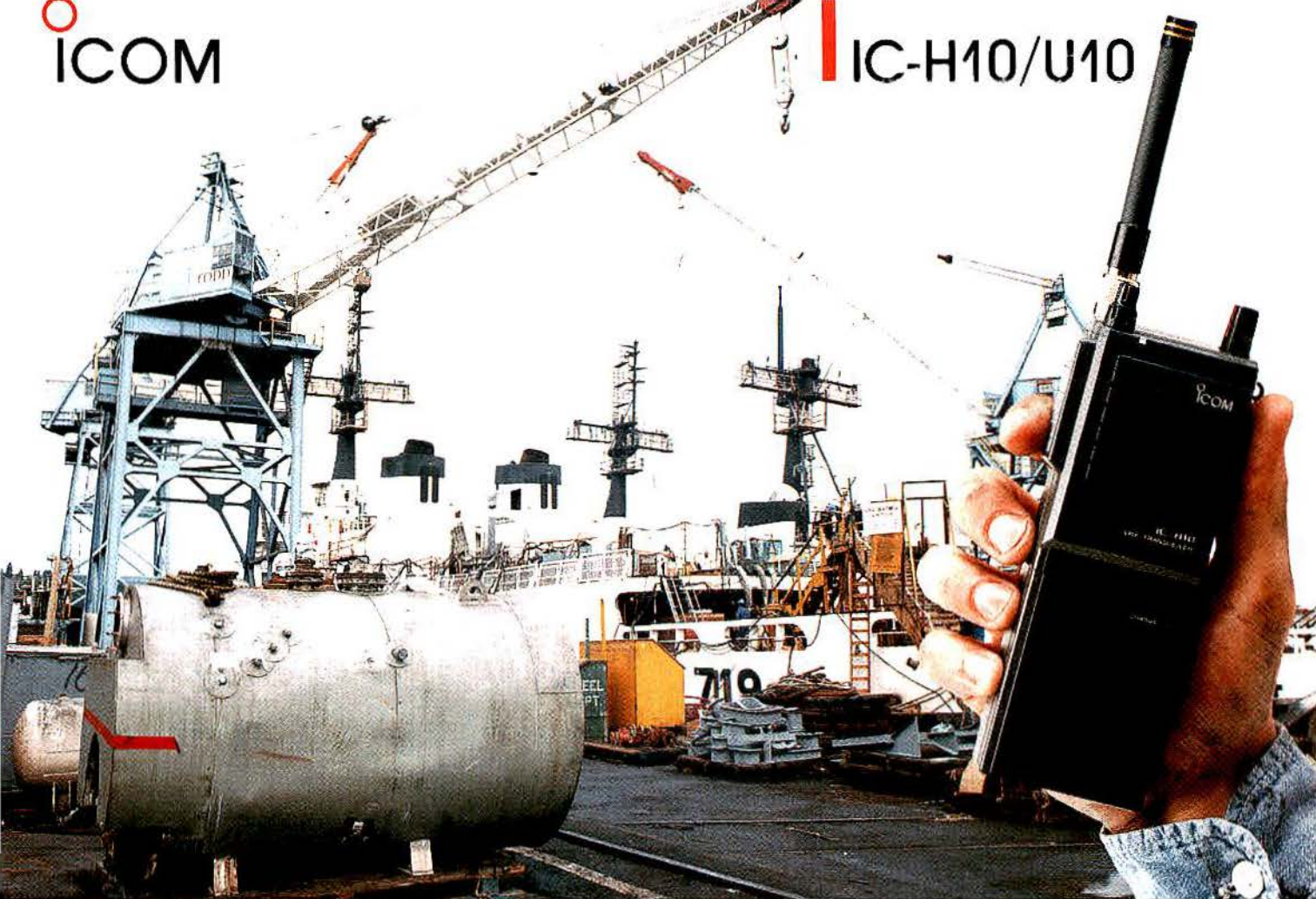
Eliason is the chief of the Law Enforcement Standards Laboratory, National Institute of Standards and Technology, formerly the National Bureau of Standards, Gaithersburg, MD.



Photo 1. Researchers take measurements for a report on field strength levels in vehicles caused by the operation of communications transmitters.

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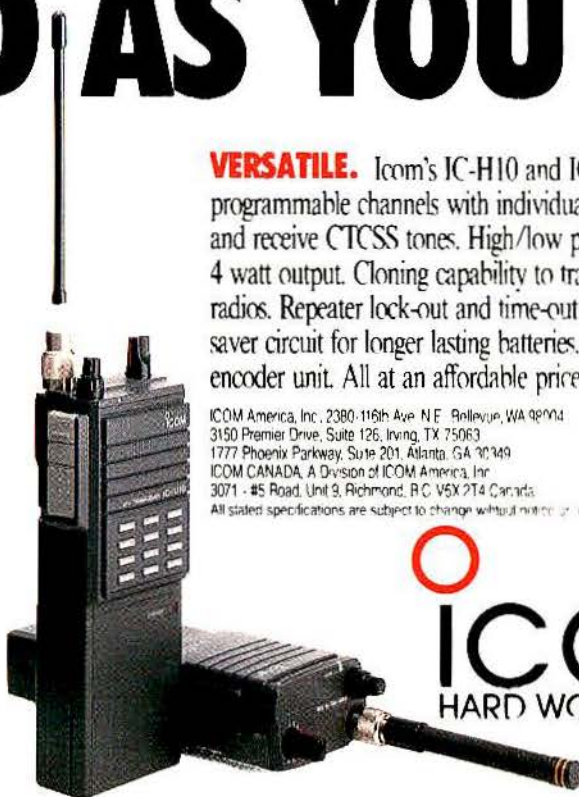
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HARD WORKING RADIOS

systems and security systems. The information center can provide details about these aspects of the program.

Standards development process

"Once the National Institute of Justice establishes project priorities consistent with Advisory Council recommendations," Treado said, "the specific project is assigned to a researcher at the

National Institute of Standards and Technology." Usually, the researcher's assignment is to develop a standard to be promulgated as a voluntary national standard.

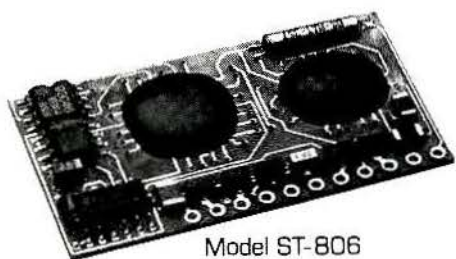
Researchers first investigate the range of commercial products available for the type of equipment under consideration. They examine any existing standards, specifications or test methods that may

apply.

When they understand the equipment's technical details, the researchers enter the laboratory phase. "Commercial units are run through their paces to devise test methods and to clearly delineate attributes critical to performance," Treado said. "Based upon laboratory study, the project staff drafts a performance standard that specifies requirements for those attributes," he said. The staff also specifies a detailed test method for each essential characteristic.

The draft standards are circulated widely among manufacturers and users

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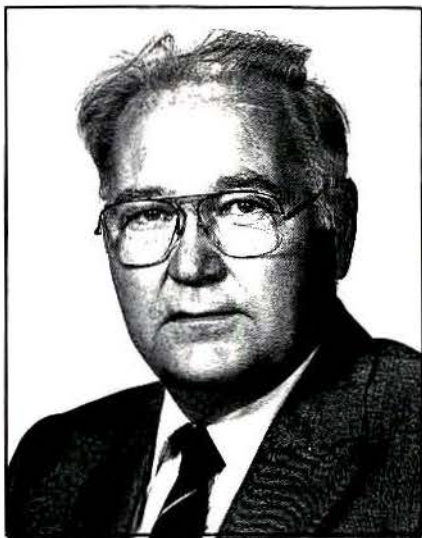
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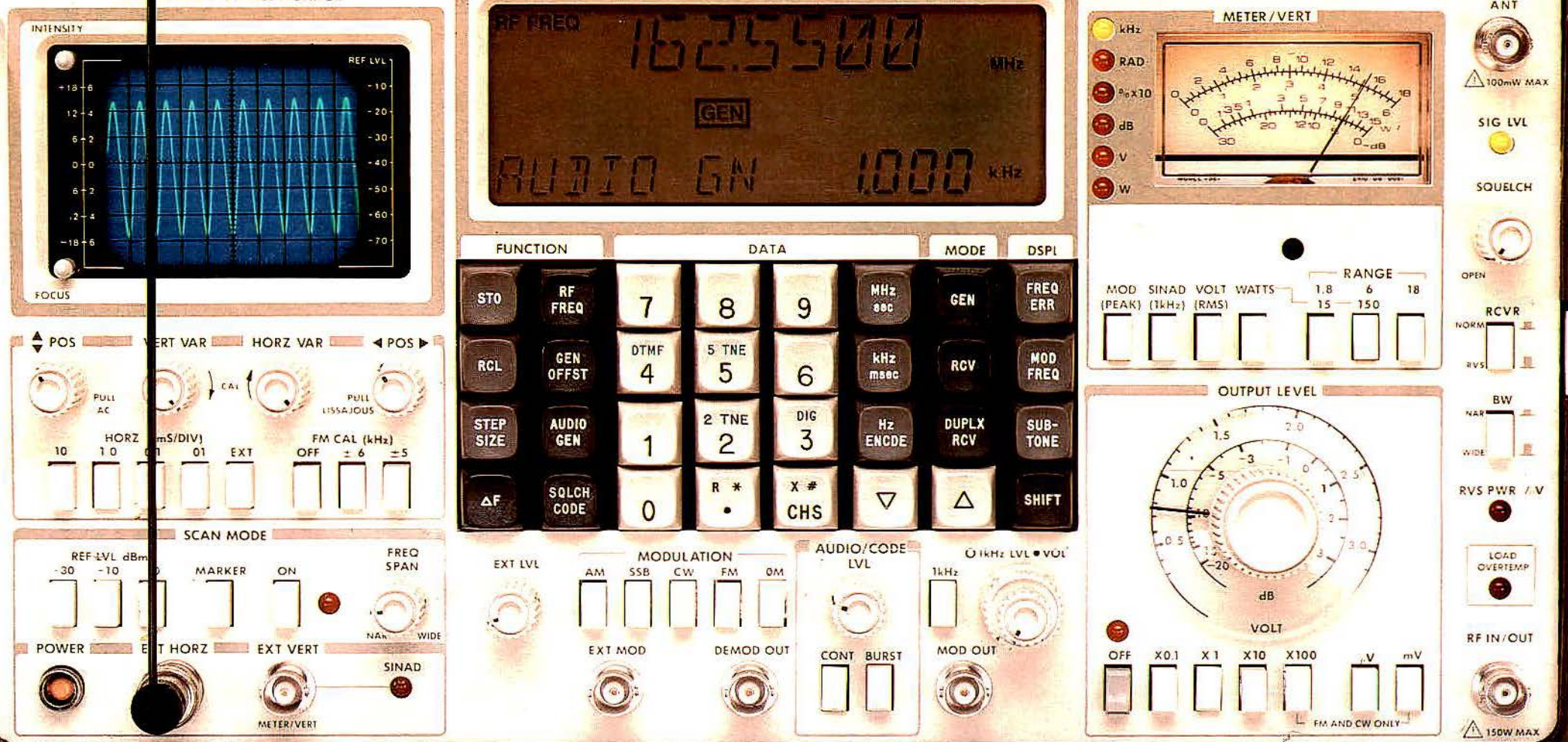


Lawrence K. Eliason is the chief of the Law Enforcement Standards Laboratory.

for comment. Then the standards circulate within government agencies for peer review. Lieberman requests approval of the standards by the National Institute of Standards and Technology editorial review board. Then NIST reviews and publishes the standards.

"The purpose of laboratory research is to develop a standard," Treado said. "During this effort, no attempt is made to rate any item of equipment as complying or not complying with the NIST standard." The reason is in part because the National Institute of Standards and Technology does not perform routine equipment testing.

Treado also pointed out that, although draft standards are circulated for technical review, the NIST standards are *not* consensus standards. "NIST assumes responsibility for the objectivity of performance requirements and test



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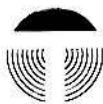
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National Institute of Justice Technology Assessment Program

Information Center

- For individual requests for information and copies of Technology Assessment Program publications:
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301-251-5060

TAPIC Search System, an on-line computer database of all NIJ documents whose full texts may be searched.

Law Enforcement Standards Laboratory

- Manages the NIJ research program.
- Formulates performance standards and tests equipment in accordance with those standards.

National Institute of Standards and Technology (formerly the National Bureau of Standards)

- Conducts research on behalf of LESL.

Advisory Council

- Assists NIJ in establishing research priorities.
- Helps to select equipment to be tested by LESL.

methods, and for making them fit the needs of the law enforcement community."

Using the standards

You can use the standards in a variety of ways.

For technicians evaluating a given piece of equipment, a single document spells out procedures to use to make bench tests.

For manufacturers, the standard delineates what is expected of equipment for each particular application.

The most obvious and intended use of the standard is in equipment procurement. Rather than developing a purchase specification from scratch, you can cite compliance with the standard as a purchase requirement.

If individual requirements differ slightly from those of the standard, simply cite modifications to the NIJ stand-

ard or add requirements that are peculiar to your needs and that are not included in the standard.

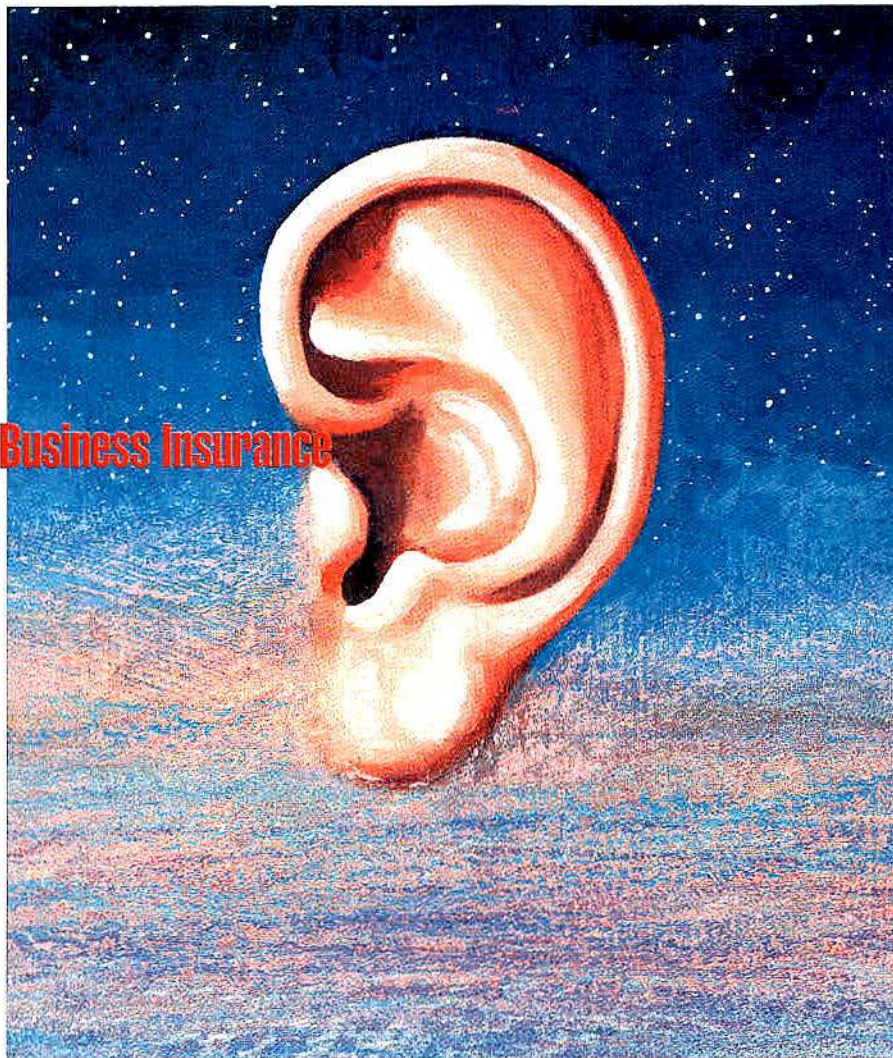
"When you use standards in the procurement process," Treado said, "do not lose sight of the benefits of competitive procurement. Although NIJ has not studied the benefits of using its standards in competitive procurement, several agencies have reported their cost savings. One saved as much as \$500,000 on a \$1 million procurement of communications systems. In no cases have savings been reported as less than 5%."

Sometimes a user needs background information to more fully understand the reason for specific performance requirements or for conducting a test in a certain way. Therefore, NIJ often issues technical reports devoted to the research conducted in developing a specific standard.

Here are some examples:

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□ "NBS-GCR-81-356, Digital Communications Techniques and Equipment for Law Enforcement Use," describes a study of typical communication message activities for several agencies. It explains the potential benefits to be derived by augmenting typical mobile FM transceivers with mobile digital equipment. It describes the characteristics of digital systems available for purchase at the time of the survey.

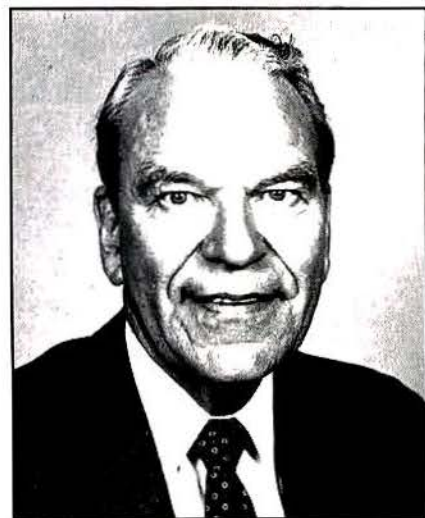
□ "NIJ Standard-0225.00, Amplitude Companded [Single-Sideband Transceivers]" is scheduled for publication this year. "NBS-GCR-86-511, The Performance of Amplitude Companded [Single-Sideband-Interim Report: A Review and Measurement Plan," an already published document, describes the early efforts in initiating the standard development project.

□ "NIJ Report 201-87, The Intelligibility of Amplitude Companded [Single-Sideband Modulation Compared to Conventional Frequency Modulation," describes that aspect of the laboratory research. All three documents resulted from research into the need for more efficient frequency spectrum use.

□ Similarly, research initiated to revise the NIJ mobile antenna standard required specific research to specify the ground plane for test procedures to determine antenna gain. "NIJ Report 200-87, Monopole Impedance and Gain

development project.

□ Similarly, research initiated to revise the NIJ mobile antenna standard required specific research to specify the ground plane for test procedures to determine antenna gain. "NIJ Report 200-87, Monopole Impedance and Gain



Marshall Treado, former communication systems program manager: "Commercial units are run through their paces."

Measurements of Finite Ground Planes," documents the research.

□ Users have asked for information to use to improve communication system design, information that may be independent of the development of a performance standard.

In one case, researchers compiled data in a publication titled "NIJ Report 200-83, Field Strength Levels in Vehicles Resulting from Communications Transceivers." The report responded to an Advisory Committee recommendation that information be made available to assist agencies in evaluating the potential non-ionizing radiation hazard to officers using communications systems. The report does not interpret the data. But it presents current exposure regulations in sufficient detail to allow the user to make an independent judgment. (See Photo 1 on page 42.)

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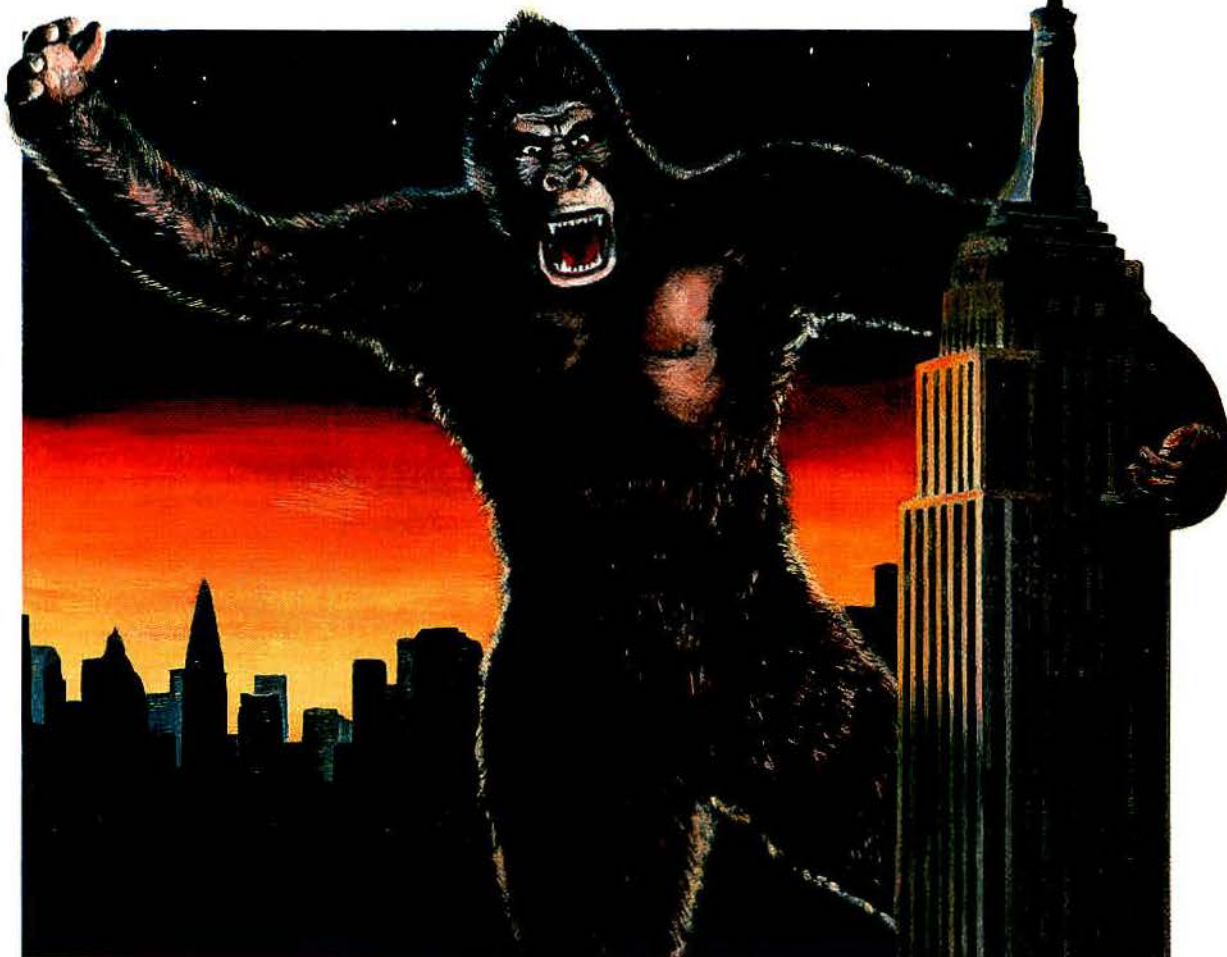
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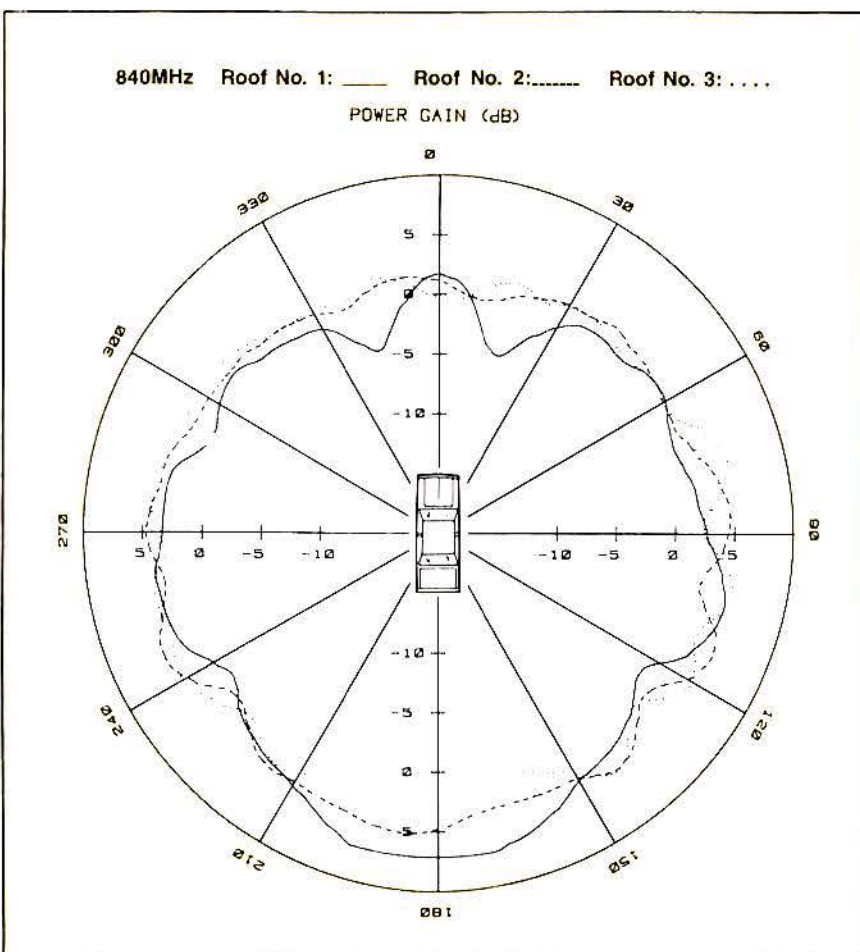


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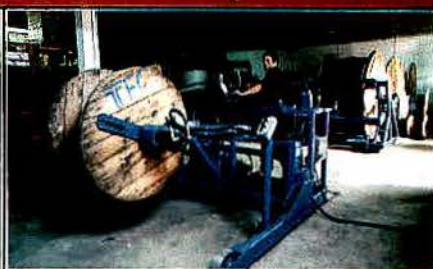
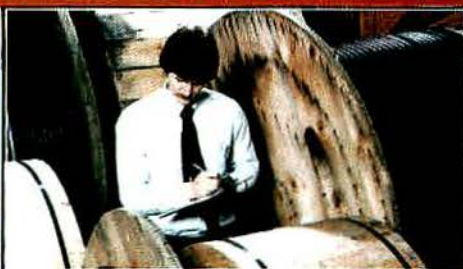
The Technology Assessment Program has produced a variety of user guides. An example is the Mobile Radio Guide, which was adapted as a three-part article published in the April,

50 *Mobile Radio Technology* February 1990

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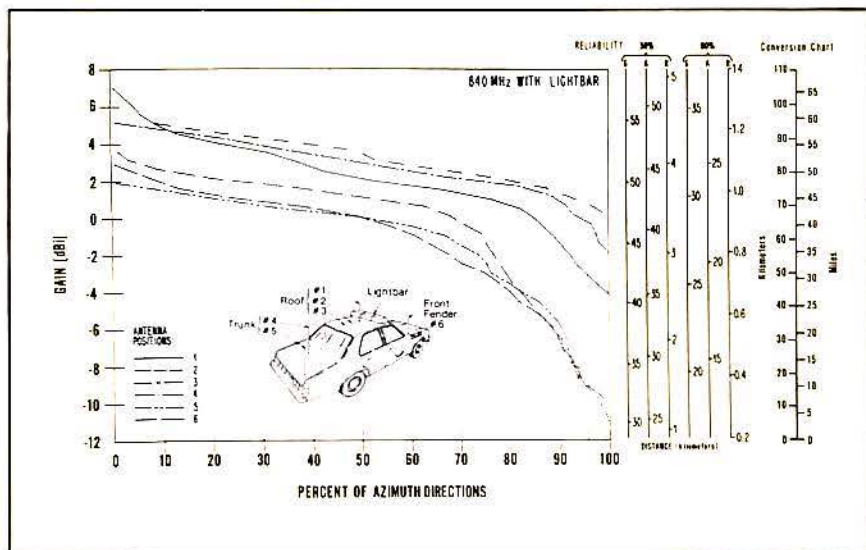


Figure 2. Communications range prediction information for six 840MHz antenna positions.

May and June 1985 issues.

Equipment comparisons

The law enforcement community recognizes and understands how useful standards are in the procurement process.

But there is a need for comparing competing products in *Consumer Reports* magazine approach. "The Advisory Council recommended that NIJ establish a mechanism to test equipment and publish the results," said Noel Bufe, the council's chairman, and director of the Northwestern University Traffic Institute. "The test results would allow departments to make direct comparisons of items of equipment."

NIJ responded by establishing an equipment testing program. The Information Center administers the program with assistance from the Law Enforcement Standards Laboratory of the National Institute of Standards and Technology.

"We solicit proposals from independent testing laboratories interested in testing equipment in accordance with NIJ standards," explained Marc Caplan, the Information Center's program manager. "The Law Enforcement Standards Laboratory assists in evaluating the proposals."

Once a contract is awarded, staff members of the National Institute of Standards and Technology's laboratory accreditation program evaluate the competence of the independent laboratory.

They conduct an on-site inspection when the first item is tested.

"Final test results from the laboratory are critically reviewed by Information Center and the Law Enforcement Standards Laboratory staff," Caplan said. "Then the test results are used to prepare an equipment performance report that fully presents all data."

Individual models of equipment that comply with the standard are placed on a Technology Assessment Program Consumer Product List.

After the initial testing, manufacturers may, at their expense, have new or additional products tested by the approved independent laboratory for future inclusion on the list.

Readers may find several equipment performance reports to be of interest, such as one for personal and portable transceivers, and another on rechargeable nicad batteries used with the transceivers.

The Information Center has finished testing vehicle tracking devices. The report is to be published soon.

Mobile digital terminals are being tested; the report will be available before long.

Two additional types of communication equipment are to be tested: body-worn transmitters and miniature surveillance recorders. It is anticipated that at least one of the test reports will be published this year.



Trade association leaders see frequency shortage, competition, consolidation

With the arrival of the new decade, all eyes are turned toward what the next 10 years will mean to mobile radio. At Expo East in Orlando, FL, Sept. 7-9, industry leaders made predictions on



Jay Kitchen: 'Welcome to the '90s and tougher competition.'

what the future holds.

"The paging industry has lots of frequencies available, but by the mid-1990s, we will face a severe shortage if the industry keeps growing at its current rate," forecast Tom Stroup, vice president and general counsel for Telocator, Washington, DC.

Nationwide and international paging are in the big picture, Stroup said. He perceives further integration of equipment and integration of paging and consumer electronics, citing that the industry already has seen such integration with the wrist-watch pager.

Stroup predicted that mobile satellite service may be substituted for cellular service in rural areas and thus serve as its competition. He foresees: "The development of mega-companies offering a full line of services such as mobile satellite paging, cellular and radio-location."

Tougher competition will evolve in

the '90s, according to NABER president Jay Kitchen. "Those that continue to 'roll with the flow' will survive. But you want to be able to do more than survive," Kitchen cautioned.

"Success stories of the '90s will be told by those who know how to deal with competition," he said. The three factors of competition are uniqueness, customer service and training.

"You don't have to be the biggest and best to compete," Kitchen said. He advocates that if companies offer uniqueness, customer service and training, they will survive in the next decade.

More depletion of spectrum in the '90s is predicted by Jack Richards, associate general counsel for SIRSA. "The FCC has fostered the growth of both SMR and cellular in the '80s and many SIRSA users are already out of spectrum in this country," he said. "SMR and cellular are up. I'm not optimistic for industrial users."

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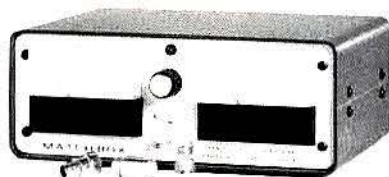
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News

Another trend Richards expects to continue is a short-staffed commission. "FCC enforcement efforts are doing more with less," he said. "There is not enough money for the FCC to embark on new enforcement efforts."

Forecasts made by Russell Fox, president of ASNA, centered on factors that will foster industry growth. These include trunking, the use of digital transmissions for SMR, channel splitting in SMR and use of mobile data terminals in SMR. "All of these will occur at some point," he said.

"For SMR, regulation is one of three factors that will determine where our industry is going," Fox said. Technology is another factor. "Competitive pressure is another."

Fox said with trunking of conventional channels, the technology is there, but FCC regulation is missing. "Private carriage below 800MHz is another area where the technology is there, but we're waiting for regulation," he added. "End-user licensing is a third area waiting for regulation."

"Digital cellular will create the growth network of the turn of the century," predicts George Calhoun, general manager of North American Group, International Mobile Machines. "Digital cellular will allow competition in the local exchange networks."

Other 1990 predictions from Calhoun:

- Spectrum efficiency will improve much more than many expect now.
- Liberalization of spectrum will be-

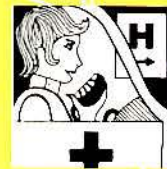


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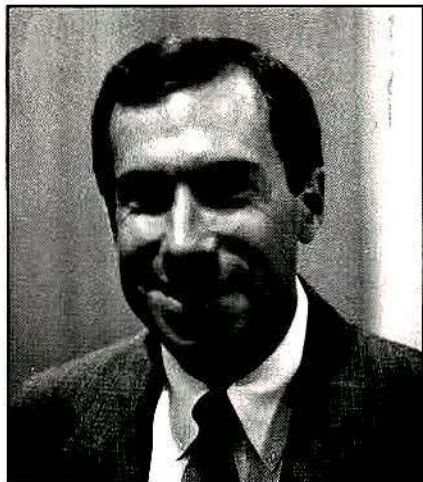


The complete text of FCC Rule
Parts 90, 94, 95, 99 and 17—
updated bimonthly.

For more information contact:
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(301) 654-6262; FAX (301) 961-6544.



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Russell Fox: 'Consolidation of industry is driven by competitive pressures.'

come widespread.

- Digital cellular will amount to 50% of the cellular revenue in 1999.
- Technology will move much farther than this industry is ready for.
- Cellular will become primarily software-based.
- Cellular stocks will undergo an apocalypse before the millennium.

Dr. Irvin Solt

Dr. Irvin "Irv" Solt, whose pioneering development work led to significant advances in high-capacity linear radio systems, including single-sideband and digital microwave technology, died Oct. 5, 1989.

TAD Radio of Canada distributes in North America

TAD Radio of Canada, Vernon, British Columbia, has signed an agreement with TAD Japan, Tokyo, to distribute TAD products in North America. TAD Radio is at 3101-29th Ave., Vernon, British Columbia V1T 1Z2; 604-545-1150. The U.S. mailing office, TAD North America, is at P.O. Box 718, Redmond, WA 98073; 206-869-5191.

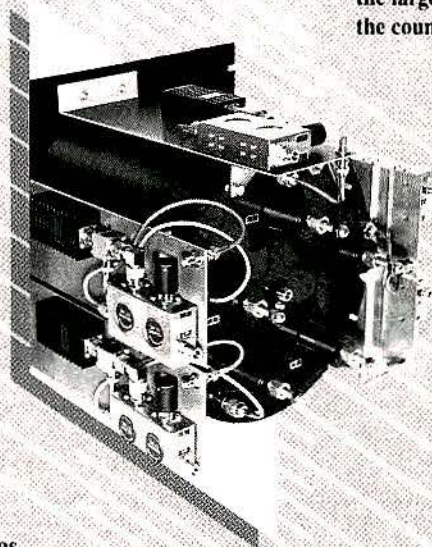
Basic names rep

Basic Communications, Laurel, MS, has selected M P Marketing of Allen, TX, as its manufacturers rep in the Texas, Arkansas, Oklahoma and Louisiana area. Basic offers the RTX Radio Telephone Exchange trunked system domestically and internationally.



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FCC field engineers fight unlicensed radio operation

Increasing numbers of unlicensed radio users form the FCC's biggest enforcement problem, according to two of the commission's field office engineers. Engineer-in-charge Ralph M. Barlow, from the Tampa, FL, field office, identified the temporary authorization procedure as a factor.

Speaking at a September FCC forum in Orlando, FL, Barlow said: "Some land mobile service representatives have a tendency to put a repeater on the air and go around and give the users a temporary authorization without frequency coordination. No one knows about it until someone needs that frequency and applies for it. The newly licensed user then finds someone already on the frequency, though there is no record of the first user. We are seeing more and more of that."

Barlow said complaints of false loading on specialized mobile radio systems are on the rise. The private radio bureau refers the complaints to field offices to



Robert McKinney: 'We had a lot of unlicensed businesses using marine frequencies.'

verify whether a system is fully constructed as a licensee reports. He said sometimes allegations have been made that an individual has applied for multiple licenses for systems within 40 miles of one another, contrary to the rules, using different names in an effort to circumvent the rules.

"These trends have developed as if to say the industry has had a free hand, and there is no one to slap it, so to speak," Barlow said.

Robert C. McKinney, the engineer-in-charge at the Vero Beach, FL, field office, said: "Unlicensed operation tends to be our primary problem. As we moved the field office from Ft. Lauderdale to Vero Beach, we've seen a big change in that we came from a metropolitan area with a lot of congested frequency usage. We had a lot of unlicensed businesses using marine frequencies. We see less of that in Vero Beach. There are plenty of frequencies in our area."



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Council member Haley proposes study manual revision, textbook

Association of Communications Technicians (ACT) council member Alex Haley has prepared a proposal for revising the National Association of Business and Educational Radio (NABER) technician certification study manual. ACT is a membership section of NABER.

"We are looking at expanding the prep manual for certification so it has a written answer for every question. A better bibliography with references for each answer would be included," Haley said. The current study manual has been criticized by some certification candidates because it lacks certain answers, and answers cannot be found in manuals readily available, either.

In addition, Haley submitted a proposal for a full textbook on mobile radio. He said sponsors probably would be needed to help underwrite the publishing because "we couldn't sell enough to support it." Haley estimates that 5,000 to 6,000 copies would be sold,

but the sale of 10,000 copies would be required for the project to be self-supporting.

NABER staffer Mark Huey said the examination manual revision project is "on hold" pending a NABER executive council approval because the project is an item that has not been budgeted.

Certification exams

The current schedule of NABER certification exams includes:

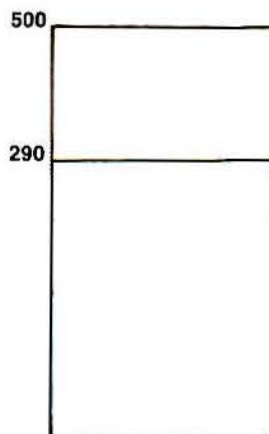
- March 23 and 24 nationwide
- March 30 at IMCE show
- May 12 at NABER's annual meeting
- May 18 and 19 nationwide
- June 23 and 24 nationwide



Information

For information about ACT, call 800-759-0300. Ask for "technician services."

ACT membership drive



During its March 1989 council meeting, ACT set a goal of adding 500 new members during the following 12 months. As of Dec. 1, 290 new members have joined.

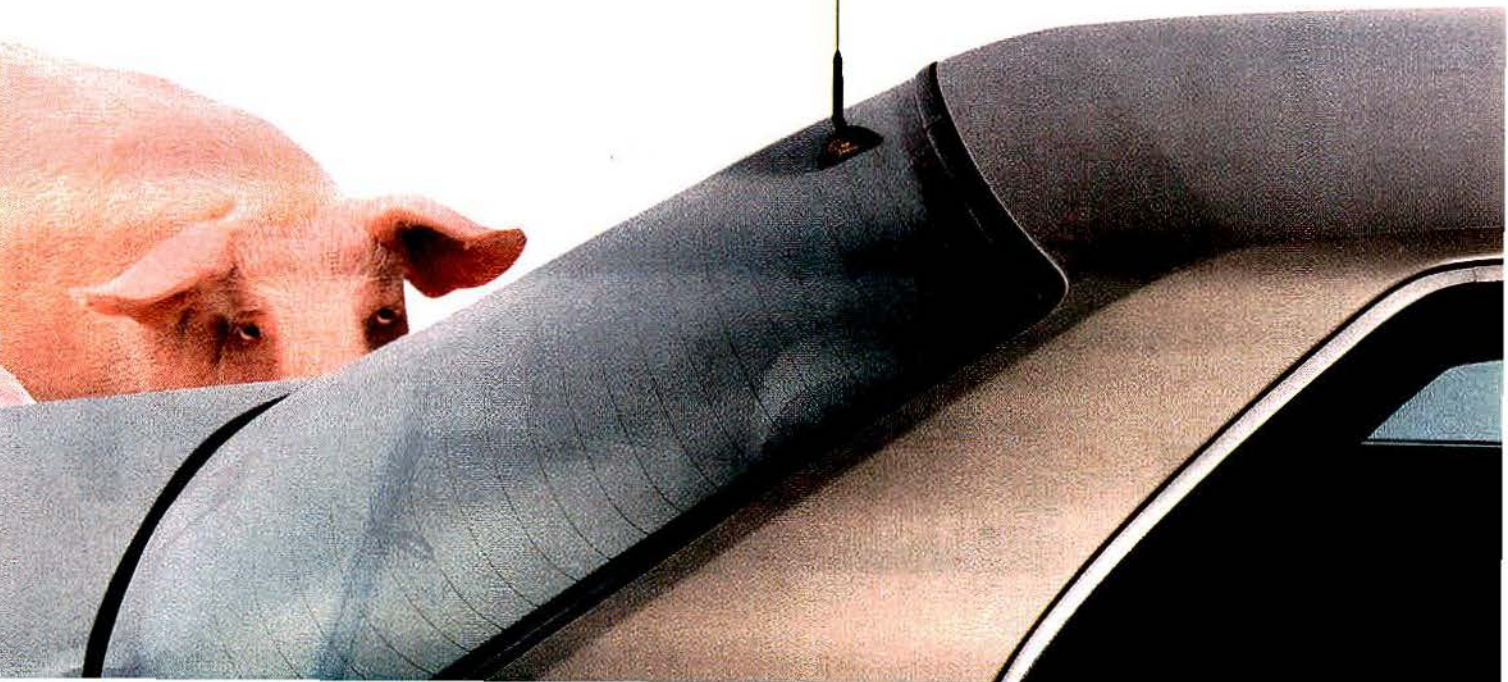
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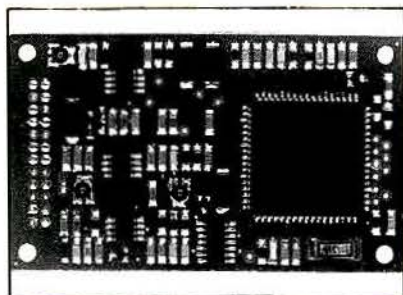
Of all the new products and services covered in the June 1989 issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them: Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

Portable spectrum analyzer covers 2MHz to 1,000MHz

Model PSA-65A portable spectrum analyzer spans 2MHz to 1,000MHz in one sweep with a sensitivity greater than -90dBm in narrow spans. The Avcom unit weighs 18 pounds and is battery- or line-operated. Options available include frequency extenders, audio demod, log periodic antennas and carrying case.

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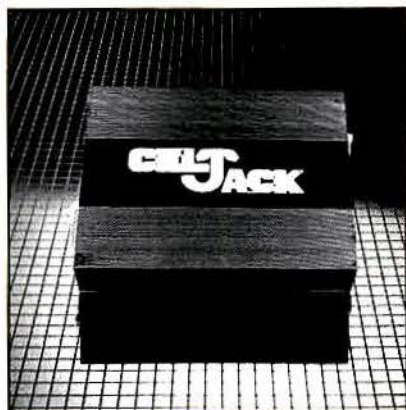
High-speed radio modem operates from 5Vdc to 14Vdc



Model HSM-5 high-speed radio modem from GLB Electronics features low-current drain and 9,600 baud or 4,800 baud data rates. The OEM subassembly interfaces a digital data source and an FM radio receiver for data transfer. It works with phase-modulated and synthesized radios and operates from 5Vdc to 14Vdc. Features include a transmission timer and a power-down mode.

Circle (276) on Fast Fact Card

Radio coupling device suits cellular use



The Celjack telephone to cellular radio coupling device from Telular features precision dial tone; female RJ11C connector; distinct tones for receiver off hook; lock; roam; pulse or tone dialing; and loop or ground start.

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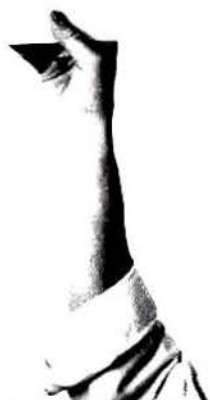
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New products

High-power VHF mobile offers one to 45 channels

The RMV60B high-power VHF mobile includes track tuning, a priority button, one to 45 channels and CTCSS. The **Relm Communications** unit offers fast scan, a time-out timer and busy channel lockout. It scans as many as 40 channels a second.



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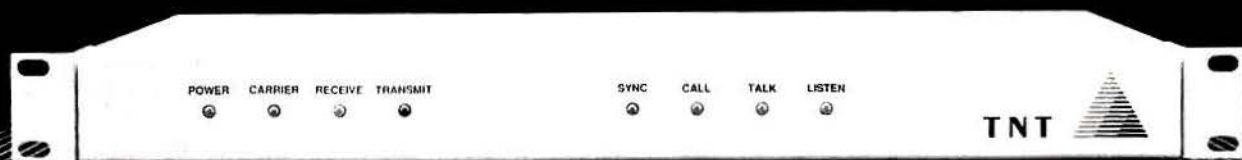
Software enhancements update terminal features

The modular voice processing (MVP) system of **Glenayre-Atlanta Operation** can be upgraded with software version 1.0, which features announce-only mailboxes; enhanced administrative screens; non-subscriber send urgent messages; auto play; and retrieve-only mailboxes.

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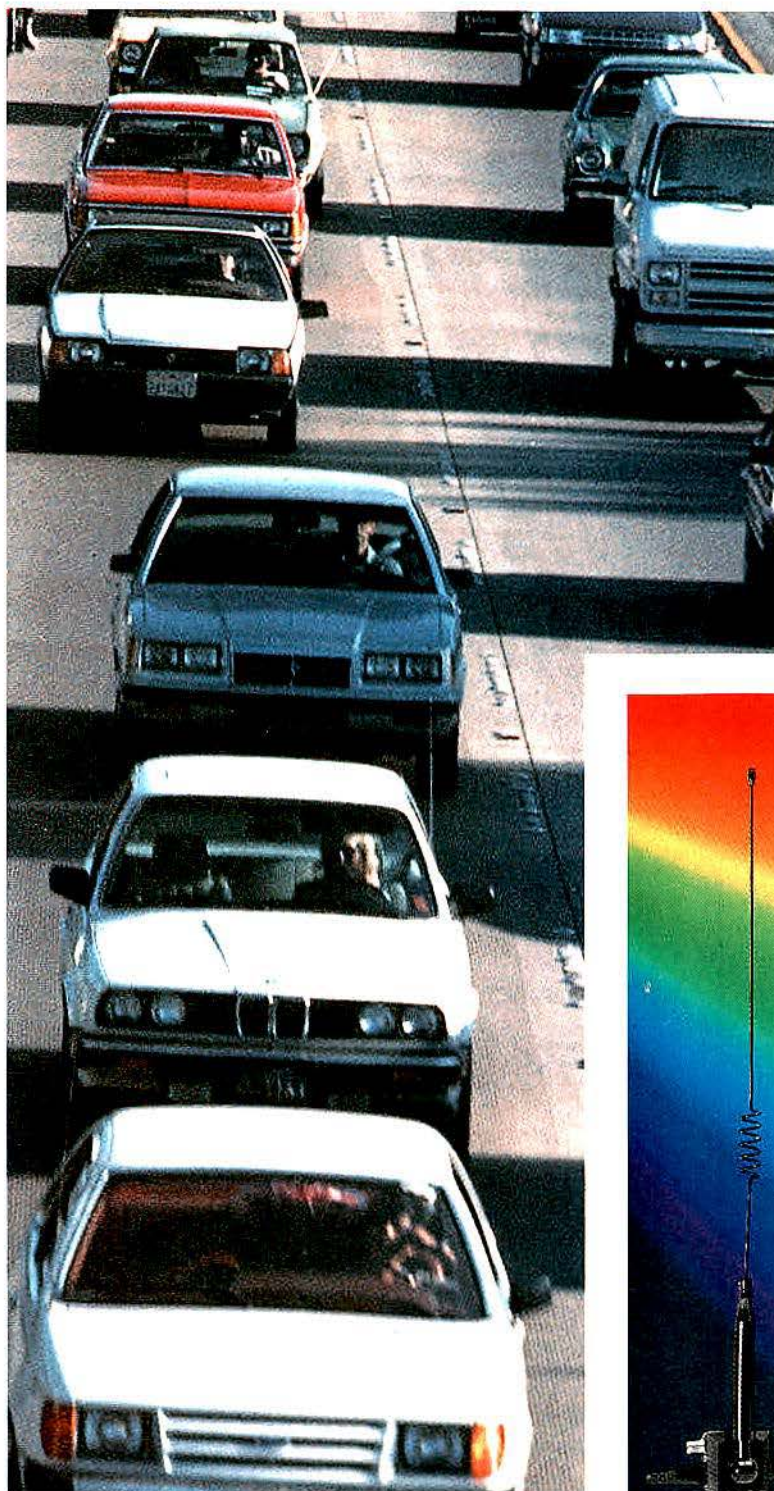
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New products

Voice announcer upgrades include caller interaction

Upgrades for the **Racom 1700X** multichannel voice storage system include a multichannel digital announcer with polling capability, the SP46; and a caller interaction function, the SP47. Both modifications enhance the 1700X, which records as many as 64 messages.

Circle (382) on Fast Fact Card

Instrument displays CTCSS tone received

The Sub Sucker made by **Automated Industrial Electronics** connects to the audio output of any business band receiver and displays the subaudible CTCSS tone being received. Model SS-1 presents tone frequency information on a front-panel LED display.

Circle (365) on Fast Fact Card

DTMF mic features field programmability



The **Astatic T, M-955M** speaker mic features frequency response of 50Hz to 5,000Hz; 10-number autodial; and field programmability from the keyboard. Designed for use with portables, the mic attaches to a lapel.

Circle (330) on Fast Fact Card

Synthesized VHF mobile covers 22 channels

The **Syn-Tech XTR VHF** mobile boasts 22 channels, expandable to 99 with a plug-in module. The mobile is available in dash- and trunk-mount versions. RF output of the **Midland LMR** mobile is programmable from 2W to 40W. The mobile can be programmed for either of two power levels per channel. Repeater talk-around is programmable by channel or front-panel selectable.



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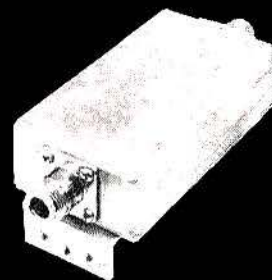
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	<i>Cellular/Trunking</i>	<i>Paging/STL</i>
FREQ.	800-900MHz	890-980MHz
VSWR	<1.1-1	<1.1-1
I.L.	<0.1dB	<0.1dB
PWR	20Ch. @ 70W	20Ch. @ 70W

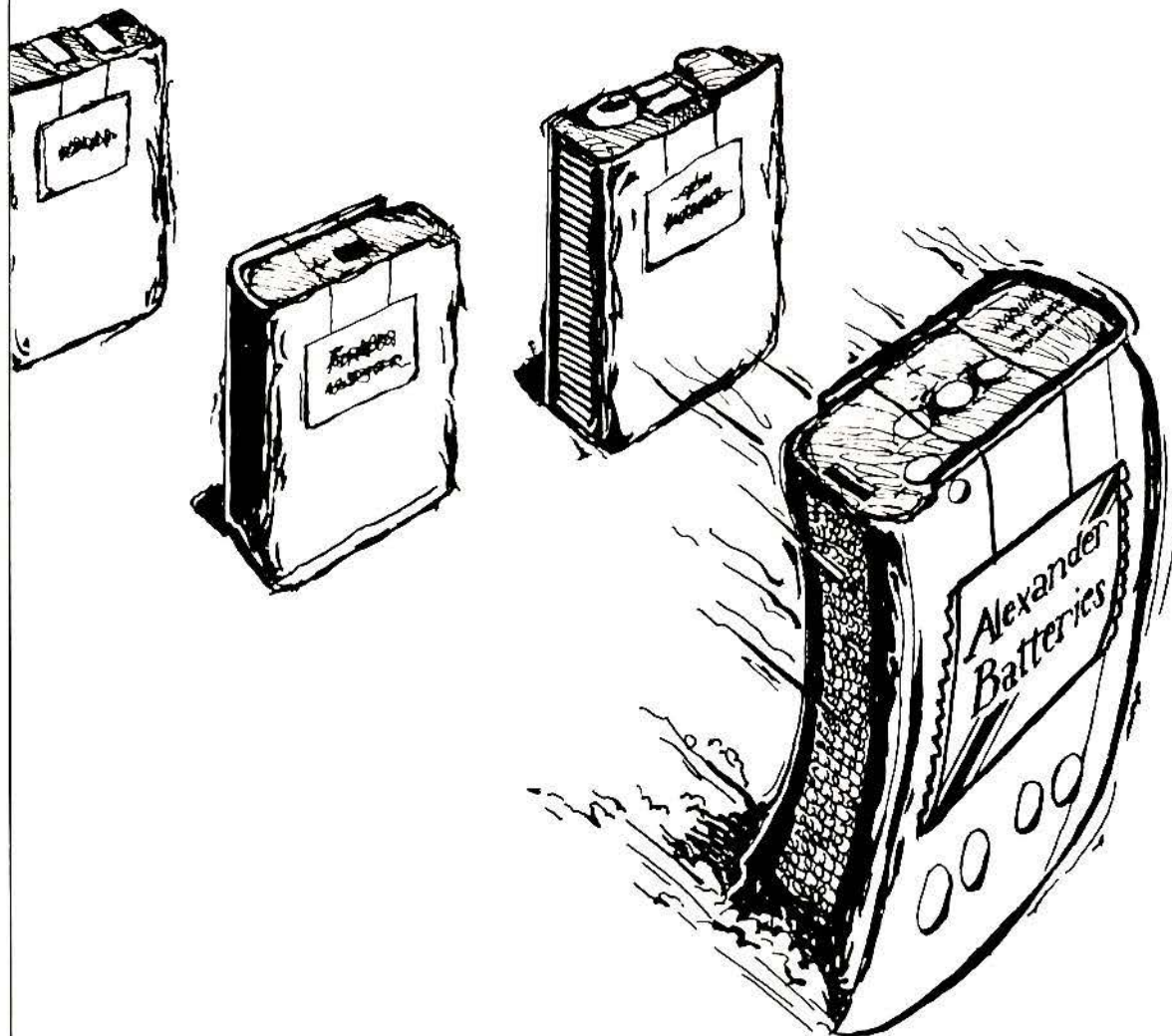
For information on these and our 450 models
of Impulse Suppressors, contact:

K PolyPhaser
CORPORATION

2225 Park Place • P.O. Box 9000 • Minden, NV 89423-9000
(702) 782-2511 • RCA Telex 272718 • FAX (702) 782-4476

Circle (59) on Fast Fact Card

LEADER OF THE PACKSM



In the race against time, Alexander batteries last longer because they're made with the longest lasting, highest quality cells available.

In addition, Alexander leads the pack in durability. Flexible circuit boards, polyswitches and other components have been designed into the line for quite some time. Now, others are jumping into the race.

What's even better is the fact we don't just win short races, but back our batteries with the strongest written warranty in the industry. In fact, we'll match any other written warranty.

And with the support of our in-the-field battery specialists, you'll find Alexander Batteries leading the pack in future technological advances, too.



Leader of the PackSM

P.O. Box 1508, Mason City, IA 50401
Tel. 1-800-247-1821 or 515-423-8955

New products

Pc programmability function added to paging terminal

Model 64 DAPT-Plus dial-access paging terminal can be programmed by a personal computer or visual display terminal with an optional circuit card. The **Zetron** circuit card provides an RS-232 port and telephone line modem. Pages can be initiated from a computer with the option installed.



Circle (347) on Fast Fact Card

Replacement batteries fit Kenwood radios



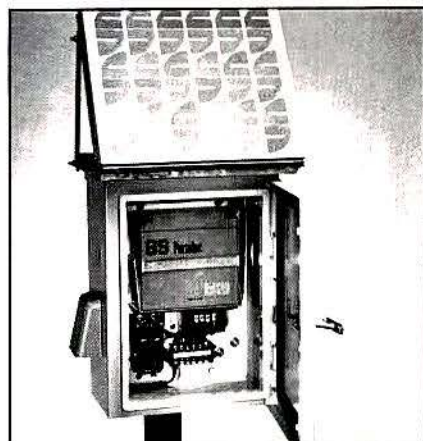
Circle (341) on Fast Fact Card

Replacement batteries for Kenwood TK100, TK200 and TK300 radios are available from **Alexander Manufacturing**.

□ Model R5621 replaces Kenwood KNB-1 battery and offers 10.8V and 490mAh.

□ Model R5622 rated at 10.8V with 800mAh capacity replaces Kenwood's KNB-2.

Solar power packs produce dc current



Self-contained solar power systems includes a photovoltaic module, a charge regulator and a sealed, deep-cycle low-maintenance storage battery. The power packs from **Heliopower** are available in three outputs. Load capacities range from 19W to 73W hours per day.

Circle (368) on Fast Fact Card

^{new} "Give Your Competition The ~~Old~~ One-Two!"

You have to be pretty sharp to stay ahead in the two-way repair business. That's why we built the COM-3. It works as hard as you do and for the money, you won't find anything as fast and powerful as the COM-3. In fact, it outperforms units costing over twice as much.

How did we do it? Simple. COM-3 is all new—new design, new electronics. You won't get bogged down by complex and antiquated technology. Instead, COM-3's advanced and powerful microelectronic circuits speed you through test routines. You get more work done, faster and easier than ever before.

And now, here's the knock out—introducing the all new Ramsey COM-7 Spectrum Analyzer. The proof is in the picture. High-

performance circuitry provides remarkable sensitivity for superb, high-resolution frequency analysis and observation. Interference location and characterization is easier than ever. Not only can you see the interference, you can hear it too. A variable bandwidth audio demodulator allows you to detect and audibly identify the interfering signals. In addition, a true frequency counter display speeds center frequency setting and reading. Frequency range covers the entire 1 MHz to 1000 MHz spectrum. Add the optional tracking generator and you can easily tune duplexers, filters and cavities!

The Ramsey COM-3 and the all new COM-7, two mean machines designed to help you knock out the two-way competition.

COM-3 COMMUNICATIONS SERVICE MONITOR **\$2795.00**

RAMSEY
RAMSEY ELECTRONICS

SPECTRUM ANALYZER **COM-7**
\$3495.00



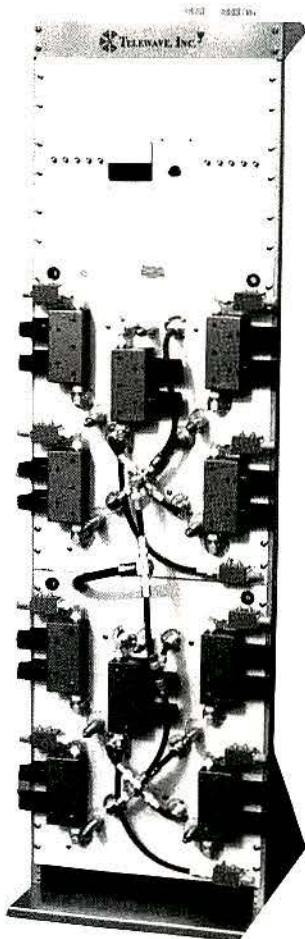
ASK ABOUT OUR EASY TO OWN LEASE PLAN Circle (61) on Fast Fact Card

Ramsey Electronics, Inc. 793 Canning Parkway Victor, NY 14564 Order Factory Direct Call 716-924-4560 FAX: 716-924-4555

POWER BREAKTHROUGH ! 200 WATTS PER CHANNEL COMBINER

(10 CHANNEL 860 MHZ)

Designed to meet the needs of today's high power transmitter and amplifier designs. You can now deliver the maximum allowable ERP to your customers through your combining system. High power combining maintains Telewave's leadership in Low-Loss combining technology. The advanced mechanical design using 3/4 wavelength cavities, assures maximum long term system performance.



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HIGH POWER JUNCTIONS

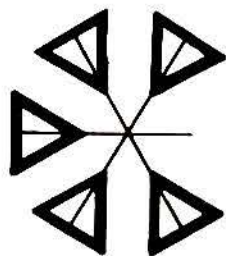
HIGH POWER LOADS

UP-FRONT MAINTENANCE

NO HIDDEN CABLES

RACK INCLUDED

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- ▼ $\pm 3\%$ -of-reading
- ▼ Wide input ranges
-100mW to 10kW and
1.5MHz to 1GHz
- ▼ Modular configuration for
flexibility, expansion, options

Bird's Model 4421 high accuracy directional RF power meter delivers readings in either Watts or dBm at the push of a button, with out charts, external couplers or attenuators.

who else but
BIRD

Separate RF power sensors - each with its own wide-band calibration profile - can be inserted anywhere in a 50-Ohm line. Calibrate Bird sensors right in your own lab with Bird's unique Model 4029 power sensor calibrator.

Send now for your free brochure with complete details.

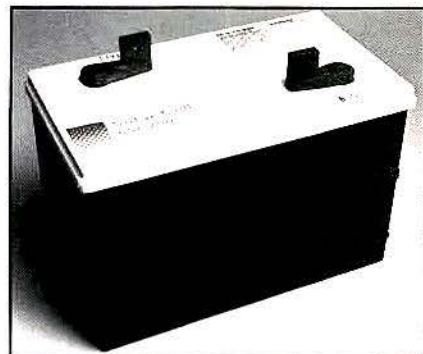
30303 Aurora Rd., Cleveland, Ohio 44139 (216) 248-1200 TLX: 706898
Bird Elec UD Western Sales Office: Ojai, CA (805) 646-7255

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Circle (63) on Fast Fact Card

New products

6V battery withstands
deep discharging



The 6SC200 6V, 180Ah gelled electrolyte battery is maintenance-free and is designed to withstand more deep discharge cycles than the average lead-acid battery. The deep-cycle battery offers three times the life expectancy of other batteries, according to **Solar Electric Specialties**. In the battery line, 12V units offered include 90Ah, 40Ah and 31Ah versions.

Circle (337) on Fast Fact Card

MORE EMI/RFI PROTECTION

HIGHER PERFORMANCE

Independent tests show Lindgren's double-electrically-isolated (DEI) design assures higher shielding effectiveness in low-frequency magnetic and high-frequency electric fields.

MORE SHIELDING SYSTEM OPTIONS

We offer a complete line of modular enclosures, cabinets, and custom rooms.

Shielding materials, in solid-sheet or screen, cover almost any shielding requirements.

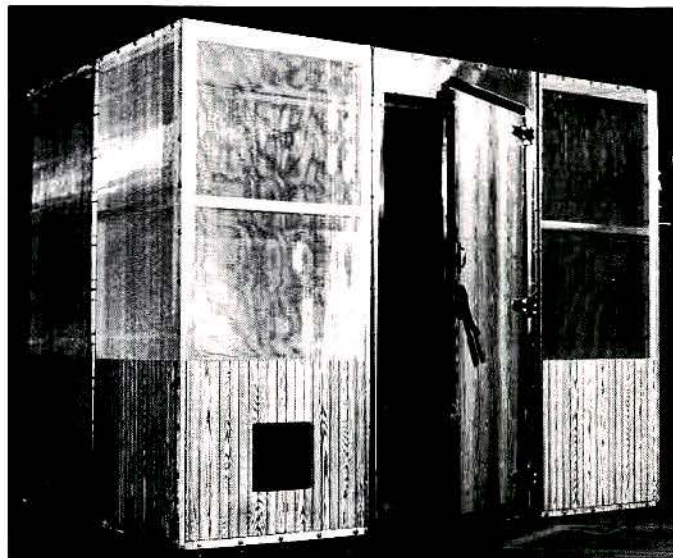
Our application engineers will help you design enclosures that meet your requirements for windows, filters for power and signal lines, wave guide feedthrus, and lights.

Other options include RF connectors, fiber-optics, special access panels, automatic doors, emergency exits, permanent ramps, and flush floors with low-rise thresholds.

EASY MODULAR ASSEMBLY

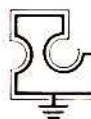
Our patented resilient clamping system permits easy assembly. Enclosures can be modified and relocated again and again without compromising performance.

Lindgren also designs and builds a variety of shielding solutions for industrial, medical, military, and scientific applications.



**ONLY LINDGREN MODULAR SHIELDING SYSTEMS
ARE ASSEMBLED, TESTED, & GUARANTEED
TO MEET SPECIFICATIONS BEFORE THEY'RE SHIPPED.**

Call us for more information and applications assistance.
708-307-7200



**LINDGREN
RE ENCLOSURES**

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Glendale Heights, IL 60139
Phone: 708/307-7200
FAX: 708/307-7571

Circle (64) on Fast Fact Card

At Motorola Cellular, big thinking creates small miracles.

In the rapidly growing cellular phone industry, Motorola is #1. We've beat all competitors in the race to introduce the world's smallest hand-held personal cellular phone. We call it MicroTAC. Others call it a "miracle" of big thinking... a major technological advance in microchips, circuit boards and the manufacturing process. And this is just one of the breakthroughs resulting from the insights and ideas of Motorola engineers, who are making a big impact on communications by making the worldwide telecommunity smaller.

If you want to shape the future of cellular technology, consider one of the following opportunities:

SOFTWARE: Real-time software development using C, UNIX*, Pascal, Ada, assembler and structured design; experience in software quality, metrics, or testing; CASE software tools (Sun, Apollo); design, programming and system debugging for telephone digital switching or data communication systems; assembler and high-level structured languages; hardware diagnostics; object oriented design, C++; software development tools such as Teamwork and Interleaf; ASN.1 (Abstract Syntax Notation); data communications protocols (CCITT #7, OSI, X.25, X.75, PAD, LAPB, LAPD, Ethernet, ISDN, CCITT V series modem, group 3 fax); modeling and simulations (GPSS, SIMSCRIPT and other simulation tools). BSEE/BSCE/BSME or equivalent. Respond to Dept. SW.

ELECTRICAL/COMPUTER: Analog and RF circuit design, receiver or transmitter RF circuits; LCD display technology, acoustics, and 8-bit microprocessor software; infrared and fiber optics; low speed data; digital modulation; 900 Mhz RF power amplifier design with hybrid or microstrip circuitry; RF device development with device vendors; parallel and/or push-pull RF amplifier design at 900 Mhz or UHF; A/D and D/A converters; RF propagation; passive and active filter theory; microwave antenna design; UL, EMI and RFI requirements; HP 3062 test system; HP 9000; digital hardware, microprocessor applications and interfaces; digital switching technology; firmware development methodology; PCM and digital telephony; digital signal processing; ASIC design; LAN systems, PSTN

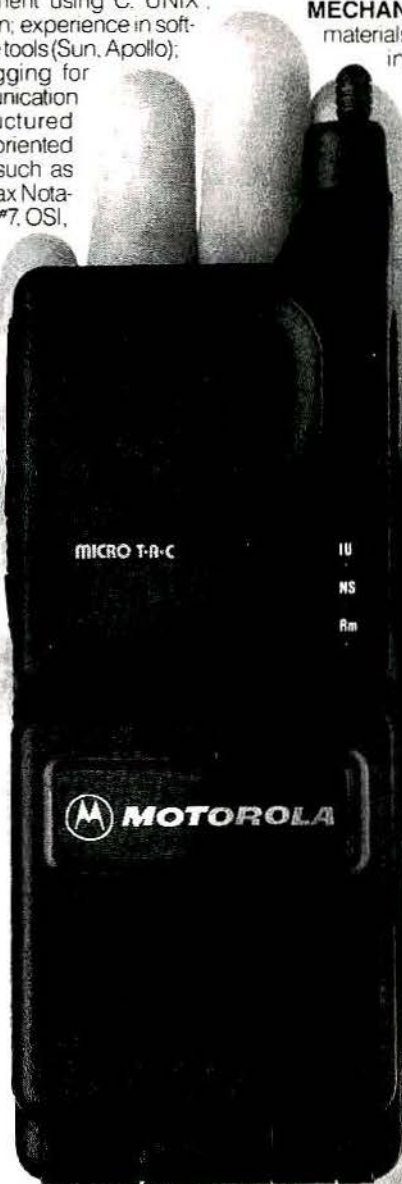
standards, ISDN standards, processor architectures, high-speed logic, 16-bit MPU design practices, programmable logic; digital modulation synchronization, adaptive signal processing, viterbi algorithm and MLSE, decision Feedback equalizer; convolutional code and linear block code, speech coding, echo cancellation, encryption; CAE techniques for digital hardware design using Mentor Graphics, etc.; data communications protocols (CCITT #7, OSI, X.25, X.75, PAD, LAPB, LAPD, Ethernet, ISDN, CCITT V series modem, group 3 fax); computer network management/administration (Apollo, Sun, Mentor Graphics, AppleTalk). BSEE/MSEE/BSCE/BSME or equivalent. Respond to Dept. EC.

MECHANICAL: Electronic packaging; CAD, CV CADD 4X; materials selection and geometric tolerances and dimensioning; extruded metal; injection molded plastics; life test procedures and factory introduction and support; plating materials and processes; structural analysis modeling; die casting and sheet metal stampings; thermal management. BSME/MSME or equivalent. Respond to Dept. ME.

SYSTEMS: Radio/cellular communication systems engineering; RF propagation prediction methods; PSTN traffic planning; telephone network, interconnection and telecommunication industry standards; microwave system design and equipment engineering; telephone switching systems; software programming skills. BSEE/BSCE/BSME or equivalent. Respond to Dept. S.

For a future with a company that will value and encourage your ideas, come to Motorola Cellular where you'll find the challenges for your big thinking. We offer an excellent salary and a comprehensive benefits package. For immediate consideration, send your resume to: Supervisor, Professional Recruitment, Motorola, Inc., Cellular Group, 1501 West Shure Drive, Arlington Heights, IL 60004. Or FAX your resume to: (708) 632-5717 (our 24-hour FAX line). To access our On-Line Career Network from your PC, dial (508) 263-3857, press return twice and key in password LEGACY. We are an equal opportunity/affirmative action employer.

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MOTOROLA

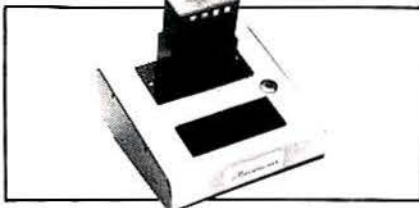
Cellular Group

Circle (65) on Fast Fact Card

New products

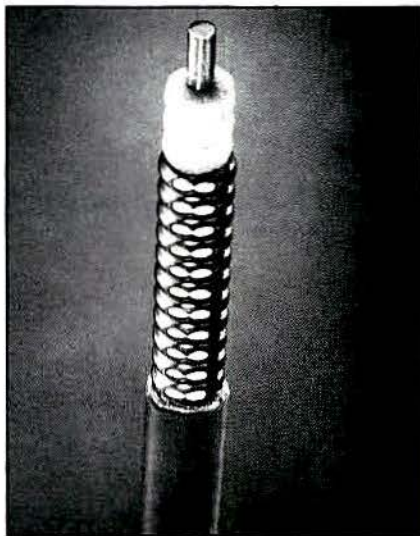
Battery analyzer accepts NiCd's

The Dowit Service Company battery analyzer, the Maintainer, features a digital readout of millampere-hour battery capacity and automatically discharges batteries to their proper level. The tester accepts a variety of nickel-cadmium battery packs for portable radios.



Circle (311) on Fast Fact Card

Slotted coaxial cable designated fire-retardant



The RXT4-3 slotted coaxial cable made by Andrew is plenum-rated fire-retardant. The cable is listed by Underwriters Lab as type CATVP.

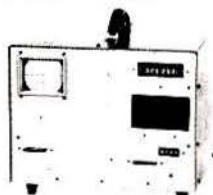
Circle (345) on Fast Fact Card

SERVICE MONITOR MEASUREMENTS MODEL FM 110

- Covers all business channels from 30MHz to 512MHz
- Monitor: 2uV, frequency error display, scope deviation display
- Generator: Calibrated output up to 10mV, Sinad display
- Built-in Tone Generator
- Full Duplex capability

\$2450.00

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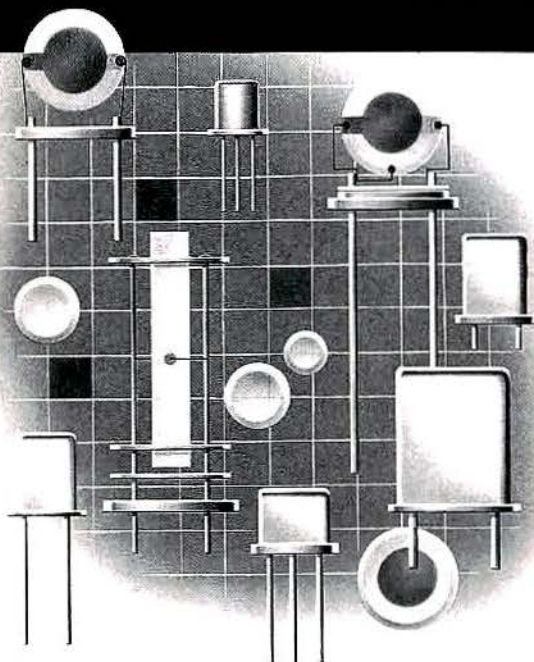
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For over 40 years, ICM has manufactured the finest in quartz crystals for every conceivable purpose.

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Need crystals for communications, telemetry, industrial, or scientific applications? Let ICM's sales department assist you to determine which type of crystal is best for you.



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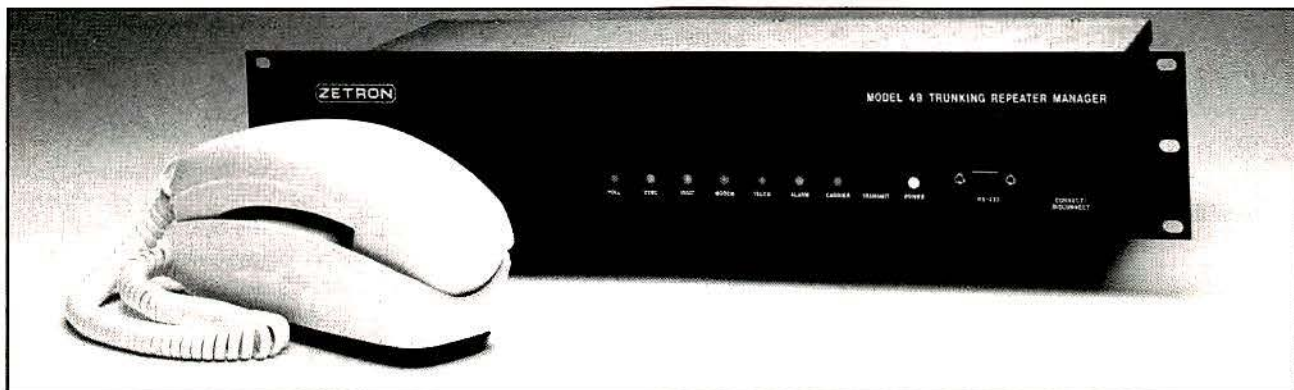
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Advancing The State Of LTR[®]



Zetron Introduces LTR Trunking Repeater Manager with Powerful Integrated Telephone Interconnect

The Model 49 Trunking Repeater Manager features:

- LTR logic, interconnect, validation, airtime accumulation, call buffer, site monitor alarm and modem in one unit
- E.F. Johnson and Uniden bus compatible
- Airtime accumulators with prime time premium
- Interconnect via End-End, DID, or E&M line
- Adaptive interconnect call limiting
- Deferred system access, time-of-day lockout
- Smart free repeater channel allocation
- Internal buffer for interconnect call detail
- Extended horn honk answer limit
- Site monitoring and mobile alarm alert option
- Full programming with a PC office computer
- Built-in 1200 bps modem
- Automatic program cloning
- Compact 3-1/2" rack mounting package



Technology That Pays

Powerful interconnect features allow you to choose End-End, DID, or E&M interface cards to adapt your trunked channel to your precise interconnect requirements.

Using Zetron's Multibase[™] advanced windowing software, you manage all your clients, on multiple sites and repeaters, from your office computer. With programmable parameters, you can easily adapt your system to your customers' changing needs.

The Adaptive Interconnect Call Limiting feature allows you to set call limits based on measured system traffic. You set the maximum number of simultaneous interconnect calls permitted for high or low priority customers. Repeaters are available for dispatch use, even if all channels are interconnected.

INTERCONNECT

DTMF Timeouts

Interdigit: 5.0 First Digit: 5.0

Regenerated Digits

Min: 07 Max: 11

Mobile Timeouts

Idle Time: 30

Max Time: 0.2

A:30 B:30

Interconnect: N

Limit Table: Y

Prefixes: Y

LOADING

Adaptive Call Limit Table

System Loading	Call In	Limits Out	Max Low	Simul High	Calls
<20%	59:00	59:00	03	05	
<40%	40:00	30:00	02	03	
<60%	10:00	15:00	02	03	
<80%	10:00	10:00	01	02	
<100%	02:00	03:00	01	02	

Zetron, Inc.
12335 134th Ct. N.E.
Redmond WA 98052

Mobile Systems Division
Phone: (206) 820-6363
Fax: (206) 820-7031

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The next logical step in the future of your service business ...

Computerizing your service operation can be a big step. But, it's one the future will most certainly demand.

We provide software and experience that can make the whole process easier and much more affordable than you may think.

From a simple service management program to a multi-user network that integrates sales, service, accounting, dispatch, repair analysis and SMR billing - we do it all ! ... and we're here to help you do it right !



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*Intelligent Software for Managers who take
their service business very seriously !*

Circle (68) on Fast Fact Card

New products

Data products include software, terminals, modems

Data communications products from **Compuquest** include a software package, laptop terminals with internal printers; internal and standalone V.32 modems for personal computers; and a protocol converter for existing modem systems.

The software package, CCP/PC, enables high-throughput and error-free data transmission over cellular and landline telephone systems.

Circle (354) on Fast Fact Card

Pc database service provides equipment lists

Upgraded national equipment location services are available from **Communications Hotline BBS**. E-Mail enhancements include hardware and software that allow more capacity; additional categories; high-speed uploading and downloading; and 24-hour free ad posting.

Circle (366) on Fast Fact Card

CW IDENTIFIER AND SITE MONITOR



ID/SM-700
\$159

Data Signal's new CW Identifier with Site Fault Monitor capability surpasses all other CW Identifiers with its versatile, user-programmable microprocessor design. The ID/SM-700 parameters are field-programmable with dip-switches and a keypad supplied with the unit, thus eliminating the need for one-time programmable PROMS.

The site monitor capability is a **FIRST** for any CWID and is completely **FREE**. This feature will continually monitor up to six site functions/activities and provide an immediate indication of any fault condition at the remote site. The site monitor is also capable of providing a periodic status of each function. The fault condition message can be displayed using the Data Signal Model SFD-700 Site Fault Decoder.

RURAL TELEPHONE



RTS-25
\$449

Data Signal's new Rural Telephone System, the RTS-25 will extend a telephone to any remote area. It is ideal for use in remote interconnects, drilling rigs, ranches, mines, cabins, etc. A standard rotary or DTMF telephone set can be used at the remote location. The RTS-25 will ring any standard telephone set. The unit is designed to automatically function with a rotary or DTMF telephone exchange. The RTS-25 is sold as a set and includes both the telephone exchange and the remote terminal units.



2403 Commerce Lane
Albany, Georgia 31708
Telephone: 912-883-4703
Toll Free: 800-652-9296

Circle (69) on Fast Fact Card

Mobiles offer data capability

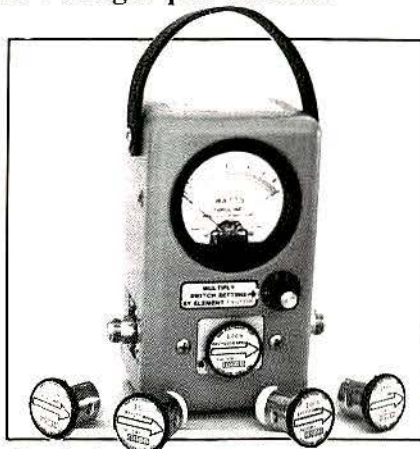


Circle (336) on Fast Fact Card

Syn-Tech FM mobiles from **Midland LMR** are available with data capability. The models are identifiable with a "D" at the end of the model number. Units include models 70-052CD and 70-056CD with 110W RF output in the 40MHz to 54MHz range; models 70-340BD and 70-440BD with 40W RF output operating in the 148MHz to 174MHz range; models 70-530BD and 70-630BD at 30W RF output and operating in the 450MHz to 470MHz range; and models 70-915D and 70-970BD at 15W covering 800MHz.

Battery-powered wattmeter offers 7 ranges per element

Model 4410A battery-powered RF directional wattmeter boasts seven power ranges per element. Made by **Bird Electronic**, standard elements provide frequency ranges from 0.2MHz to 2,300MHz and power ranges from 0.002W to 10,000W. Other versions available include model 4411 battery-powered portable or 115V/230V ac operation; model 4412 rechargeable NiCd battery or 115V/230V ac operation; and model 4410P 19-inch rack panel-mounted unit with battery or 115V/320V ac operation.



Circle (358) on Fast Fact Card

B1225 VOICE ALARM

Works with all normal 2-way radios

FEATURES

- Electronic voice storage.
- You record your voice in RAM.
- 1 site ID & 8 alarm inputs per unit.
- All parameters field programmable.
- Remote alarm acknowledgement.
- The B1225's own vocabulary talks you through the programming.
- 4 DTMF controlled relay outputs (unit verbally confirms relay output).
- Transmits DTMF, 5 tone, 2 tone or single tone with voice message.

TYPICAL APPLICATIONS

- Oil company facilities eg: batteries, ESD valves, compressors.
- Municipal facilities eg: water level, intrusion alarms, pump monitor.
- Remote radio sites eg: AC power failure, battery voltage, tower lights.

BENEFITS

- Reduced down time.
- Site security.
- Safety.
- Cost effective.

DEALER PRICE US \$449.



Quality Telecom Supply Ltd. (403) 293-1965

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FAX (403) 285-2202

Circle (70) on Fast Fact Card

Hutton has what it takes!

HELIAX®

Hutton Communications is now your direct connection to **ANDREW HELIAX®** in large quantity or small. Hutton can supply all of your next HELIAX®, Superflexible, or Radiax® order with your choice of connectors installed and guaranteed. PLUS we have hoisting grips, hangers and grounding kits IN Stock. Check off your next order and call HUTTON.

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Main Feeders

- ☐ 1/2" Heliax® _____ ft.
- ☐ 7/8" Heliax® _____ ft.
- ☐ 1-1/4" Heliax® _____ ft.
- ☐ 1-5/8" Heliax® _____ ft.

Jumpers

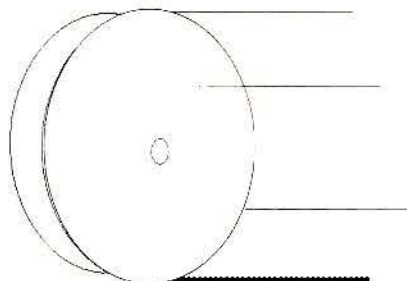
- ☐ 1/4" Superflexible Jumpers
- ☐ 1/2" Superflexible Jumpers

Heliax® Accessories

- ☐ Hoisting Grips _____ pcs.
- ☐ Tower Hangers _____ pcs.
- ☐ Standoff Kits _____ pcs.
- ☐ Grounding Kits _____ pcs.
- ☐ Connectors _____ pcs.

Now we're rollin'

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Reels or Boxed

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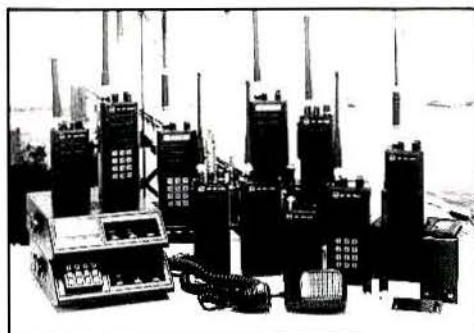
Sales Agency
Hutton National
9810 FM 1960, Suite 215
Humble, Texas 77338
713-446-4060
800-325-8950
Fax: 713-446-5779

Circle (71) on Fast Fact Card

Two-Way Radios

Hand Held And Mobile

Superior Quality Rugged And Reliable



Immediate Shipment From Stock

- VHF - UHF
- Synthesized
- Crystal Controlled
- "Mini" And Standard Size
- Custom Requirements
- Accessories
- 2 Year Warranty

HAEWA CORPORATION 

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Norcross, GA 30093 USA Fax: 404-921-2896

Dealerships Available

Circle (72) on Fast Fact Card

New products

Replacement batteries
fit Motorola Saber radios



Replacement batteries for Motorola Saber series radios are available from **Alexander Manufacturing.**

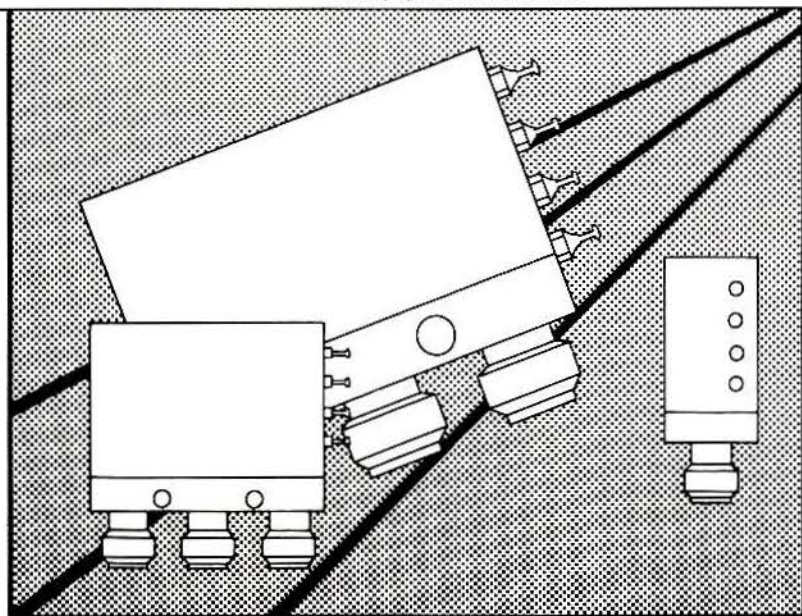
☐ Model H4592 with 7.5V and 500mAh capacity replaces Motorola NTN4592.

☐ Model H4593 7.5V and 900mAh battery replaces NTN4593A.

☐ Model H4594 7.5V and 1.3Ah battery replaces NTN4594A.

☐ Model H4595 with 7.5V and 1.8Ah replaces NTN4595A.

Circle (356) on Fast Fact Card



JFW Industries, Inc.
5134 Commerce Square Dr.
Indianapolis, Indiana 46237
(317) 887-1340

RF Power

Cold Switch
100 Watts average
500 Watts peak
Hot Switch
20 Watts average

VSWR

1.3:1 maximum

DC Supplies

+15 Vdc (@ 250 mA)
+5 Vdc (@ 40 mA)

Frequency Range

100-500 MHz

Control (1 line)

TTL

Insertion Loss

.4 dB maximum

RF Connectors

SMA, TNC, or N Female

Isolation

50 dB minimum

Switching Speed

100 microseconds

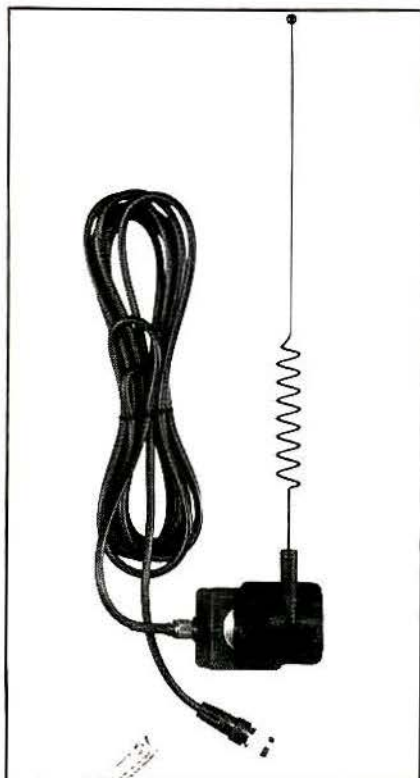
HIGH POWER SWITCHES

Solid-State Power Switches That Require Only Low Voltage DC Power

JFW

Circle (73) on Fast Fact Card

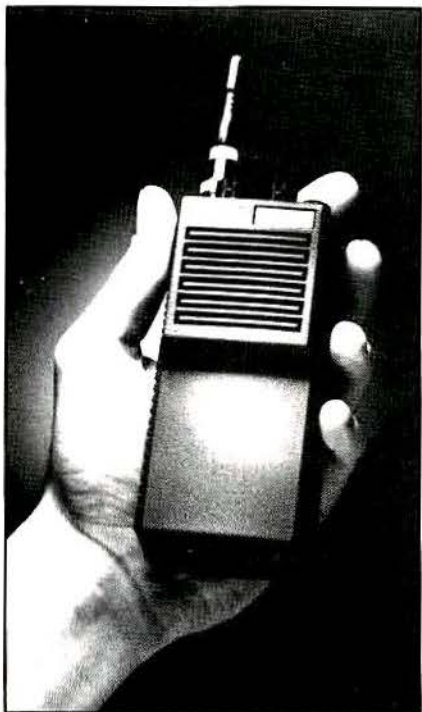
Glass-mount antenna
features tunability



The K-2 cellular glass-mount antenna from **Antenna Company** features a 3dB gain and can be fine-tuned electrically.

Circle (409) on Fast Fact Card

Voice scrambler is built
into mini 5W portable



The Tech Talk 5W, four-channel portable unveiled by **Advanced Videotech** features a built-in voice scrambling module. The module uses frequency inversion to render communications unintelligible to eavesdroppers.

Circle (439) on Fast Fact Card

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Base Station Antennas

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and
Celwave RF

Super Stationmaster™ UHF base antennas incorporate certain design enhancements not available in other fiberglass collinear antennas. The for instance, the PD455 combines 10MHz bandwidth with improved lightning protection while preserving the desirable lightweight characteristics of the antenna. The PD755 keeps the same electrical specifications of the PD455 while providing outstanding ruggedness for really severe weather locations. Celwave antennas comply fully with the EIA329 standards for testing antenna gain.

Hutton can supply a wide range of Celwave RF products from antennas to multi-port combiner systems to many sizes of Celwave-coaxial cable. Hutton is your very best choice for your supplier of Celwave Super Stationmaster™ antennas and any of the other fine Celwave RF products

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Circle (75) on Fast Fact Card

B1260 VOICE ALARM

For your Radio System and/or Telephone

FEATURES

- Electronic voice storage.
- Custom alarm announcements.
- 8 optically isolated inputs per unit.
- Remote alarm acknowledgement.
- Transmits DTMF, 2 tone or single tone with alarm message on radio.
- All operating parameters are field programmable (locally or remotely).
- Auto-dialing of 8 phone numbers.
- Shares radio channel and phone line.
- Works on party lines.

TYPICAL APPLICATIONS

- Oil company facilities eg: batteries, ESD valves, compressors.
- Municipal facilities eg: water level, intrusion alarms, pump monitor.
- Remote radio sites eg: AC power failure, battery voltage, tower lights.

BENEFITS

- Reduced down time.
- Site security.
- Safety.
- Cost effective.



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Circle (74) on Fast Fact Card

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Circle (76) on Fast Fact Card

New products

Unit combines paging,
two-way communications



The 102/P pager-portable from ICM Communications covers 144MHz to 174MHz. The unit operates as a tone and voice pager with a 1W transceiver. It suits a two-sequential system: The unit decodes two-tone sequential signal tones that correspond to the address code, allowing a voice message to be heard.

Circle (320) on Fast Fact Card

Interconnectability



Midian Electronics is proud to bring you exactly what you've been waiting for: **INTERCONNECTABILITY.** Our new DTMF encoder/decoder microphones, dash mount boxes, and modules offer you all the features you want, including connect and disconnect ANI, 10 Number Memory Dial, Last Number Redial, Busy Lockout, Time Out Timer, Dial Tone Pause, Call Routing Digit, Individual, Group, and All Call, Multiple Ring Tones, and Deadbeat Disable. Call 1-800-MIDIAN'S to find out more about Interconnectability.

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Circle (77) on Fast Fact Card

Control module fits Uniden mobile for trunked use

The RTX-UNIS 500-4051 mobile control unit installs in Uniden's SMU mobile to enable trunked operation on

Basic Communications' RTX system. The module offers group and individual decode and ANI.

Circle (374) on Fast Fact Card

Battery charger, analyzer discharges 1V per cell



The Optimizer NiCd battery charger and analyzer operates with the push of a button. It uses a negative delta voltage method of detecting full charge. The Alexander Manufacturing unit discharges a battery to 1V per cell. The condition mode automatically charges, discharges and recharges a total of three cycles. The charger and analyzer is available in one- or three-unit models.

Circle (355) on Fast Fact Card

900MHz trunked mobiles offer 15W RF output

The LTR 8640 and 8644 trunked mobiles from E. F. Johnson feature 15W output; 10- or four-system trunking; system scan; 900MHz channel operation; front-panel control; and external EEPROM programming. The dash-mount radios are housed in a die-cast chassis that meets military standard 810C and D for shock and vibration.



Circle (367) on Fast Fact Card

B1225 VOICE ALARM

Works with all normal 2-way radios

FEATURES

- Electronic voice storage.
- You record your voice in RAM.
- 1 site ID & 8 alarm inputs per unit.
- All parameters field programmable.
- Remote alarm acknowledgement.
- The B1225's own vocabulary talks you through the programming.
- 4 DTMF controlled relay outputs (unit verbally confirms relay output).
- Transmits DTMF, 5 tone, 2 tone or single tone with voice message.

TYPICAL APPLICATIONS

- Oil company facilities eg: batteries, ESD valves, compressors.
- Municipal facilities eg: water level, intrusion alarms, pump monitor.
- Remote radio sites eg: AC power failure, battery voltage, tower lights.

BENEFITS

- Reduced down time.
- Site security.
- Safety.
- Cost effective.

DEALER PRICE US \$449.



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Circle (78) on Fast Fact Card

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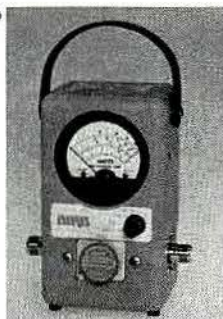
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10	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
25	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
100	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
250	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
500	\$5.00	\$5.00	\$5.00	\$5.00	\$5.00
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Circle (79) on Fast Fact Card

New products

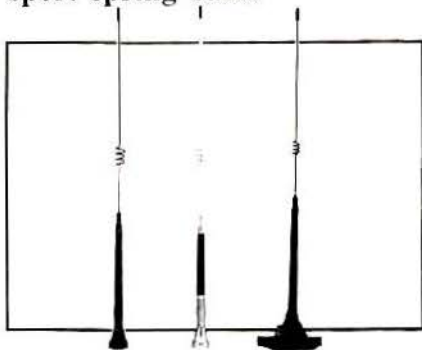
18-channel mobiles are expandable to 36

UHF and VHF mobiles, the GX2000, come with 18 channels and are expandable to 36 channels. The **Standard Communications'** units offer rugged construction and wideband operation. A time-out timer is standard.



Circle (352) on Fast Fact Card

Elevated feed antennas sport spring bases



Three elevated feed antennas added to Ora Electronics' Total Coverage line offer 3dB gain, heavy-duty spring bases and multifaceted elevated shafts. Model CMS6206 features a body mount configuration. Model CMS6506 has rubber protection pads for trunk-lip mounting. Model CMS6606 has a gold mast whip and lower base and suits body-mount applications. The models come with 16 feet of cable and TNC connector.

Circle (316) on Fast Fact Card

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Circle (80) on Fast Fact Card

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minimize delay time and increase channel loading capacity.

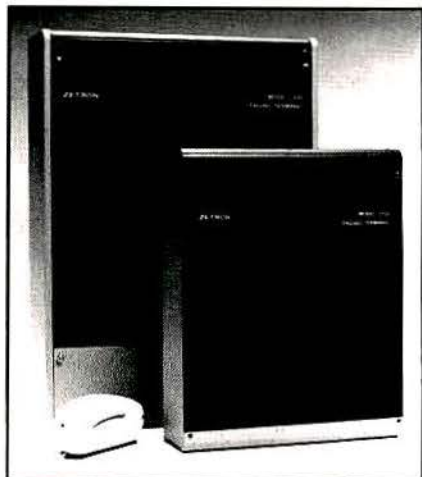
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Circle (81) on Fast Fact Card

Multiple frequency decoder adapts paging terminal



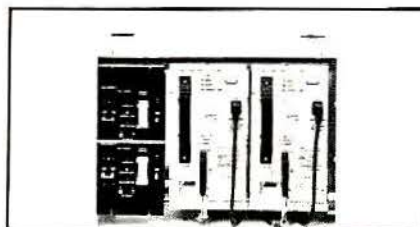
A multiple frequency (MF) decoder board option is available from Zetron for its series 2000 paging terminals. The MF decoder card attaches to a "dual trunk card" in the series 2000 paging terminal.

Circle (343) on Fast Fact Card

Power system includes switchmode rectifiers

TwinPack power systems from Power Conversion Products feature modular design and a mounting shelf with controls for two switchmode rectifiers; $\pm 24V$ and $-48V$ systems are available. Rectifiers are convection-cooled and have an 88% efficiency rating with a power factor of 97% minimum.

Circle (360) on Fast Fact Card



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Circle (82) on Fast Fact Card

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Circle (83) on Fast Fact Card

Catalog describes monitoring systems

Lucas Ledex offers a brochure on its signal and communication monitoring system. Information includes systems that test, monitor, control, extend or adapt existing telecommunication systems. Systems for monitor and control applications are detailed.

Circle (373) on Fast Fact Card

Monthly dispatcher news boasts employment listings

Dispatch Publications offers a monthly dispatcher newsletter. It averages eight or more pages per month of general interest articles. Regular contents include a calendar of events; employment news; and information available to dispatchers.

Circle (342) on Fast Fact Card

Brochure explains RF power meters

Bird Electronics details its high-accuracy, laboratory-grade RF power meters, models 4420 and 4421, in a brochure that also includes descriptions of power sensors and power sensor calibrators.

Circle (377) on Fast Fact Card

Catalog features soldering tools

Ungar describes its updated line of soldering and desoldering equipment for the electronics industry. Its catalog describes construction features, specifications, military-spec compliance, ordering information and tip selection.

Circle (378) on Fast Fact Card

Market study reports cellular telephone sales

Cellular Brand Sales for December 1988 released by Herschel Shostek Associates measures cellular telephone sales by brand and manufacturer.

Circle (379) on Fast Fact Card

Brochure features communication structures

Rohn's communication structures are explained in a brochure that contains a brief history, applications, professional support, quality control, construction, hot dip galvanizing, shelters, mounts and towers.

Circle (380) on Fast Fact Card

Data sheet details remote status reporter

Model 2900 remote status reporter from Lucas Ledex is described in data sheet 2900. The unit offers dial-up reporting, 12 alarm inputs, battery backup with ac power failure alarm and automatic test timer.

Circle (257) on Fast Fact Card

Alarm, control system brochure is offered

Status monitoring and control of remote communications, industrial and commercial facilities is described by Raven Electronics in a brochure on its series 422 alarm and control system.

Circle (419) on Fast Fact Card



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... IF YOU'RE CONCERNED ABOUT SAFETY, RELIABILITY AND PERFORMANCE. STI-CO antennas are chosen by law enforcement agencies because of our total disguise, top quality workmanship, trustworthiness, and for the innovative technology that goes into every STI-CO product.

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Circle (84) on Fast Fact Card

Respondents see simulcast advantages for wide-area coverage

Motorola, Glenayre Quincy Operation (formerly Quintron), General Electric and Glenayre Electronics are the top four manufacturers of simulcast equipment, according to respondents to the July "What Do You Think?" questionnaire. Since the survey was conducted, Quintron was acquired by Glenayre Electronics and was renamed. The majority of respondents are common carriers, followed by private carrier paging and mobile phone operations.

The majority of respondents, 81.5%, said they see a need for simulcasting for their respective systems. Types of systems respondents represent include multiple responses as follows:

SYSTEMS OPERATING	%
Paging	92.6%
Two-way radio	63.0%
Data transmission	29.6%
Other	18.5%

The majority of respondents, 63%,

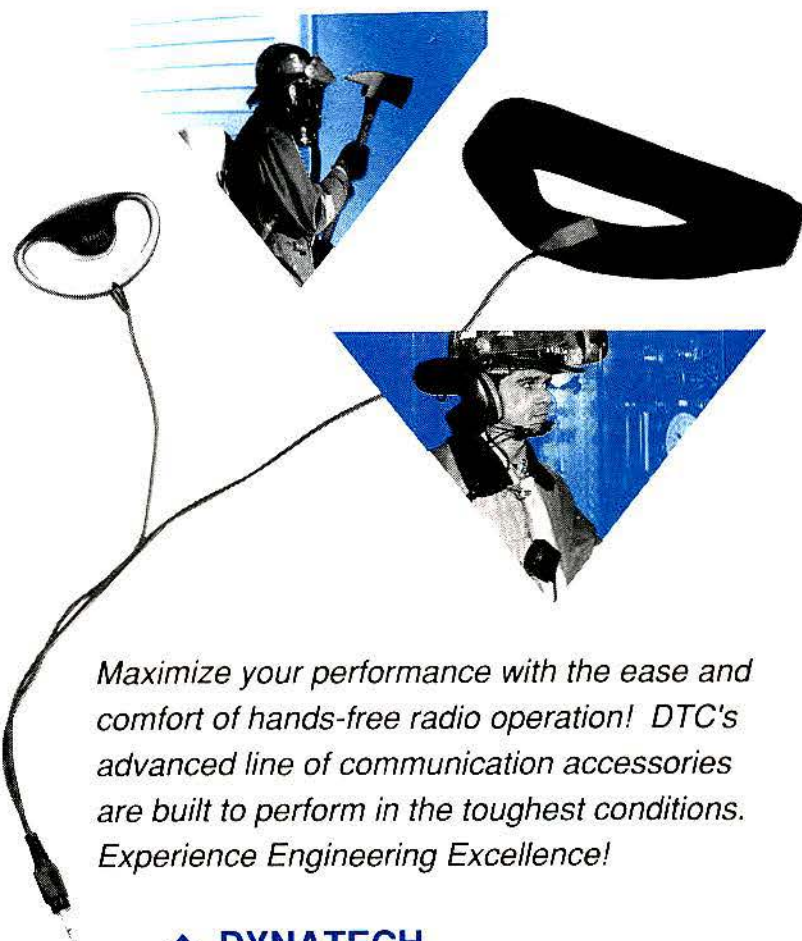
plan to purchase simulcast equipment in the next 12 months with 29.6% reporting they have no intention to purchase equipment in the next 12 months, and 7.4% did not respond.

Those planning to purchase simulcast equipment reported various applications for the equipment, including expansion

for paging area; private carrier paging; mobile phone use and paging; simulcast extended local and wide-area paging; and public safety systems.

Advantages respondents see in simulcast systems are varied: "It provides wide-area coverage without additional frequencies being required." "In pag-

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Be sure to answer this month's "What Do You Think?" questionnaire on page 97 and return it to us so your responses can be included in a future "Feedback" column.

What do you think?

How do you view the PCP market?

1. What are your views on the PCP market?

2. What are your views on the PCP market?

3. What are your views on the PCP market?

4. What are your views on the PCP market?

5. What are your views on the PCP market?

6. What are your views on the PCP market?

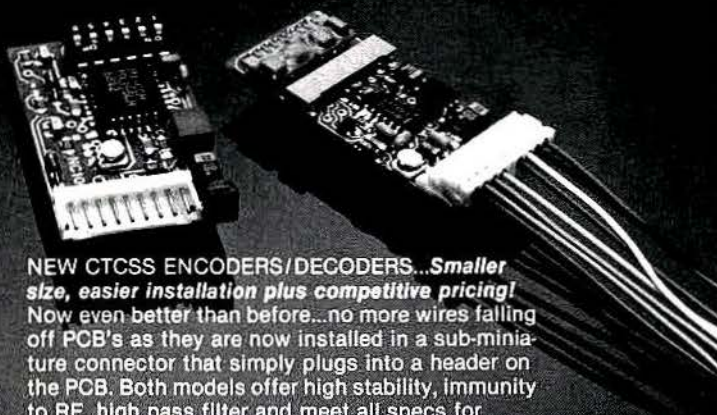
7. What are your views on the PCP market?

8. What are your views on the PCP market?

9. What are your views on the PCP market?

10. What are your views on the PCP market?

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Circle (86) on Fast Fact Card

Feedback

Simulcast advantages

- Wide-area coverage
- Spectrum efficiency
- Fill-in for dead spots
- Reliable coverage
- Competitive edge

ing and data, it is very useful." "To be competitive."

"To combine stand-alone systems, give customers better service and to be competitive." "Provides reliable system coverage; provides wide-area and multi-city coverage." "It provides greater range—today's mobiles can go farther."

Responses continue: "It provides inherent coverage enhancement and signal back-fill in rough or uneven terrain." "Increases coverage area while using frequencies most efficiently."



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Circle (87) on Fast Fact Card



LaCombe



Williams



Phipps

Norm LaCombe exits Yaesu U.S.A., Cerritos, CA, as executive vice president to rejoin Standard Communications, Los Angeles, as national sales manager.

Janice Williams leaves the training staff at Zig Ziglar to become national training coordinator for Graphic Scanning's Radio Paging Division, Dallas.

Don Phipps leaves Kenwood, Long Beach, CA, to join Bendix/King Radio, Lawrence, KS, as marketing manager.

Daryl Domask exits Allied Electronics as major account representative to join PowerPak, Morton Grove, IL, as inside sales and marketing specialist.

Steve Galek becomes general manager at Nedco Electronics, Morton Grove, IL.



Express yourself

Something bothering you? Want to sound off about it?

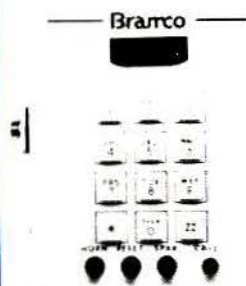
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Circle (88) on Fast Fact Card

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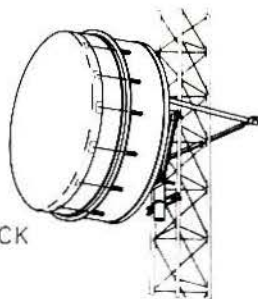
Circle (89) on Fast Fact Card

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ON HIGH PERFORMANCE

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Circle (90) on Fast Fact Card

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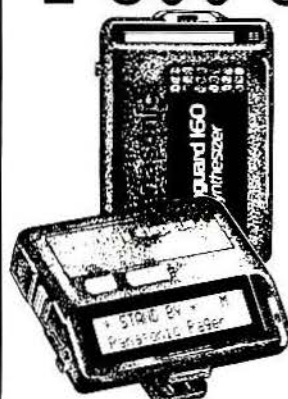
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Circle (91) on Fast Fact Card

Calendar

February

5-7—Cellular Telecommunications Industry Association
1990 Winter Meeting and Exposition, Ballys, Reno, NV.
Contact: 202-785-0081.

19-22—Gulf Coast Regional Associated Public-Safety
Communications Officers, Landmark Hotel, Metairie,
LA. Contact: Glen Dastugue, 504-349-5300.

March

11-14—Energy Telecommunications and Electrical
Association '90, San Antonio Convention Center and Hilton
and Marriott hotels, San Antonio, TX. Contact:
214-578-1900.

20-22—Western Regional Associated Public-Safety Com-
munications Officers Meeting, Doubletree Hotel, Albu-
querque, NM. Contact: John Brown 505-888-8123 or Gigi
Baca, 505-768-2410.

22-24—Telocator Spring International Convention, San
Diego Convention Center, San Diego, CA. Contact:
800-422-4862.

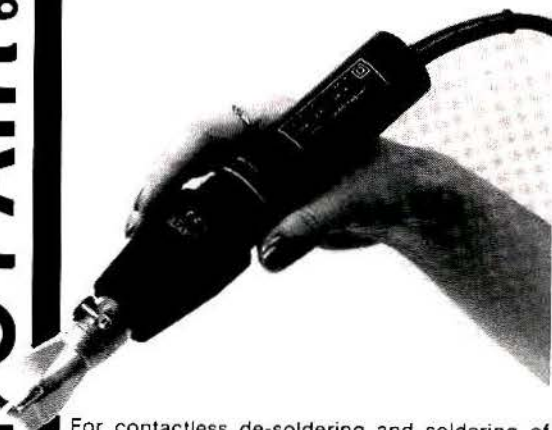
28-30—International Mobile Communications Expo,
Dallas Convention Center, Dallas. Contact: 303-220-0600.



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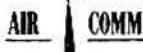
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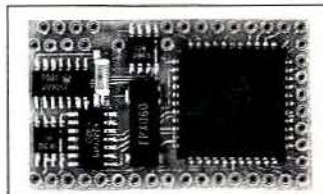
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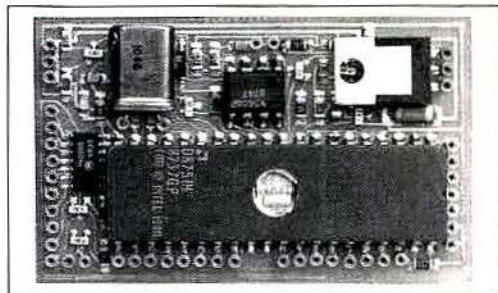
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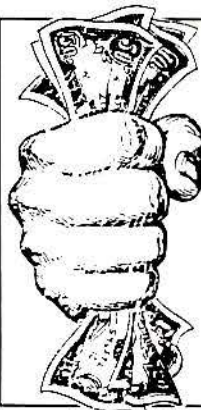
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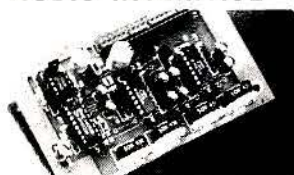
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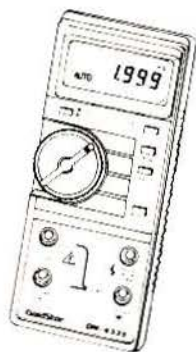
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Regency, Wilson, Octagon, Maxom, etc.

- References available
- Fast turn
- \$30.00/hr. (2 hr. max. + parts)
- UPS paid return

TA Enterprises

986 Cherokee Rd. SE • Palm Bay, FL 32909

407-725-6167

Tim Downey, President

PAGER REPAIR

Low-cost conversion

Discounts for quantity

Repair: Flat rate-\$10 plus parts.

Call Pager Communications
for quotes: (512) 341-6514

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